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ABSTRACT

The Biological Effects of Electromagnetic Radiation serves as a vehicle through which current documentation of research highlights on the biological effects and health implications of nonionizing electromagnetic radiation (microwave and radio-frequency radiation) are compiled, condensed, and disseminated on a regular basis. BEEMR is intended to be a highly useful current awareness tool for scientists engaged in research or related activities, the great number and diversity of relevant publications make imperative the availability of this service to persons whose work requires that they keep abreast of current developments in the field.

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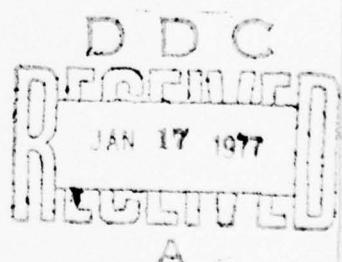
BIOLOGICAL EFFECTS OF ELECTROMAGNETIC RADIATION

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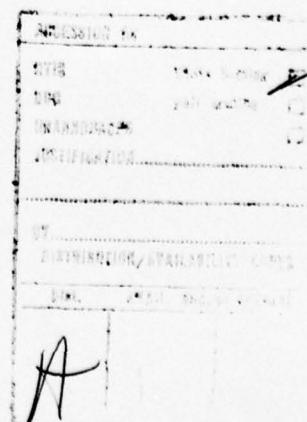
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Literature Selected and Abstracted
by
THE FRANKLIN INSTITUTE RESEARCH LABORATORIES
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Biomedical Section
Bruce H. Kleinstein, Ph.D., Technical Editor



PREFACE

Biological Effects of Electromagnetic Radiation is a publication researched and prepared by the Franklin Institute Research Laboratories, Science Information Services Department, under a grant from the U. S. Army Research Office. The grant is co-sponsored by the Bureau of Radiological Health, Food and Drug Administration; Office of Naval Research; U. S. Navy Bureau of Medicine and Surgery; U. S. Air Force School of Aerospace Medicine; and the Walter Reed Army Institute of Research. The U. S. Environmental Protection Agency is cooperating in this project.

This digest serves as a vehicle through which current documentation of research highlights on the biological effects and health implications of nonionizing electromagnetic radiation (microwave and radiofrequency radiation) are compiled, condensed and disseminated on a regular basis. *Biological Effects of Electromagnetic Radiation* is intended to be a highly useful current awareness tool for scientists engaged in research or related activities. The great number and diversity of relevant publications make imperative the availability of this service to persons whose work requires that they keep abreast of current developments in the field.

Biological Effects of Electromagnetic Radiation is published quarterly. The issues of Volume II, and future volumes, will include materials received during the preceding three months. Each issue will include news items and announcements, a listing of meetings and conferences, abstracts of current literature, and a directory of current research. Materials for which full text is not available will be included as citations. When available, a special report section, technical note, book review, or topical retrospective literature survey will be included.

ABBREVIATIONS AND ACRONYMS

- A -

A, amp - ampere
ac - alternating current
AECH - application of electric current to the head
AF - Air Force
AMP - adenosine monophosphate
ANSI - American National Standards Institute

- B -

BRH - Bureau of Radiological Health
BSI - British Standards Institute
BUN - blood urea nitrogen

- C -

c - cyclic
C - centigrade
CISPR - Comite International Special des Perturbations Radioelectrique (Special International Committee on Radio Interference)
CL - Current Literature
cm, cm² - centimeter, square centimeter
CMF - constant magnetic field
CNS - central nervous system
CPK - creatine phosphokinase
cps - cycles per second
CR - Current Research
CW - continuous wave

- D -

dB - decibel
dc - direct current
DOD - Department of Defense
DRL, drl - differential reinforcement of low rates

- E -

E, \hat{E} - electric field
ECG - electrocardiogram
EEG - electroencephalogram
EHF - extremely high frequency
ELF - extremely low frequency
EM - electromagnetic
EMC - electromagnetic compatibility
EMF - electromagnetic field
EMI - electromagnetic interference
EMP - electromagnetic pulse
EMR - electromagnetic radiation
EPA - Environmental Protection Agency
ES - electrostatic
ESF - electrostatic field

- F -

f - frequency
FDA - Food and Drug Administration
FFA - free fatty acids
FI - fixed interval
FM - frequency modulation
FR - fixed ratio

- G -

g - gram
G - Gauss
GHz - gigahertz
GI - gastrointestinal

- H -

H, \hat{H} - magnetic field
Hb - hemoglobin
HEW, DHEW - Department of Health, Education, and Welfare
HF - high frequency
HHT - hypothalamic-hypophysial-thyroid
hr - hour
Hz - hertz

- I -

IEEE - Institute of Electronic and Electrical Engineers
IMPI - International Microwave Power Institute
i.p. - intraperitoneal
IR - infrared
IRT - interresponse time
ISM - assigned industrial, scientific and medical frequencies
i.v. - intravenous

- J -

J - joule
JPRS - Joint Publications Research Service

- K -

kA - kiloampere
kg - kilogram
kHz - kilohertz
km - kilometer
kV - kilovolt
kW - kilowatt

- L -

l - liter
LD₅₀ - 50% mortality
LDH - lactic dehydrogenase
LF - low frequency
LH - limited hold

- M -

m, m² - meter, square meter
mA - milliampere
mc - megacycle
MF - magnetic field
mg - milligram
mho - unit of measurement of conductivity
MHz - megahertz
min - minute
ml - milliliter
mm - millimeter
mmho - millimho
mOe - millioersted
mon - month
mW - milliwatt
Mw - megawatt
MW - microwave
mV - millivolt

- N -

N₂ - nitrogen
NBS - National Bureau of Standards
NIH - National Institutes of Health

ABBREVIATIONS AND ACRONYMS

Biological Effects Electromagnetic
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NIR - nonionizing radiation
nm - nanometer
NSF - National Science Foundation
NIOSH - National Institute for Occupational Health
and Safety
NTIS - National Technical Information Service

- O -

Oe - oersted
ONR - Office of Naval Research
OSHA - Occupational Safety and Health Administration
OT - Office of Telecommunications
OTP - Office of Telecommunications Policy

- P -

P - pulsed
PEMF - pulsed electromagnetic field
PFD - power flux density
PHS - Public Health Service
PMF - permanent magnetic field
pp - pulsed power
pps - pulses per second
PRF - pulse repetition frequency
PRR - pulse repetition rate
PW - pulsed waves

- R -

R - Roentgen
RBC - red blood cell
RF - radiofrequency
RMF - rotating magnetic field
RNA - ribonucleic acid
rpm - revolutions per minute

- S -

s.c. - subcutaneous
sec - second
SGOT - serum glutanic oxalacetic transaminase
SHF - super high frequency
SW - shortwave

- T -

TEM - transverse electromagnetic mode
TLC - thin layer chromatography
TSEE - thermal stimulated exo-electron emission
TSH - thyroid stimulating hormone

- U -

U - unit, units
UHF - ultra high frequency
US - ultrasound
USAFSAM - U. S. Air Force School of Aerospace Medicine
USDA - U. S. Department of Agriculture
UV - ultraviolet

- V -

V - volt
VA - Veterans Administration
VLF - very low frequency
vol - volume

- W -

W - watt

WBC - white blood cell
WG - waveguide
WHO - World Health Organization
wt - weight

- Y -

yr - year

SYMBOLS

ϵ - dielectric constant
 $\hat{\epsilon}$ - complex permittivity
 λ - wavelength
 μ - micro
 σ - specific conductance
 Ω - ohm
 γ - gamma

NEWS ITEMS

DEVELOPMENT OF A MICROWAVE DIATHERMY STANDARD

The FDA has announced its intent to develop a radiation safety performance standard for MW diathermy equipment which is used in heat treatment for aching muscles and joints. The BRH believes recent technical developments for control of unnecessary radiation associated with these units makes a performance standard both feasible and desirable. Comments received after August 1, 1975, may be considered depending on the stage of development of the standard at the time they're received. Comments should be sent to The Hearing Clerk, Food and Drug Administration, Room 4-65, 5600 Fishers Lane, Rockville, Md. 20852. *FDA Consumer* 9(5):30, 1975

MICROWAVE OVEN RECALL

General Electric will recall 17,800 MW ovens that may leak as much as 10 times the amount of radiation allowed by federal regulations. GE's corrective program includes letters to dealers and oven owners. The owners are advised to discontinue use until they can be examined by the manufacturer. All of the ovens use a wire mesh seal around the door which prevents MW energy from escaping when pressed tightly around the door. The major reason for the reported leakage is warped frames which cause gaps around the doors. *FDA Consumer* 9(5):30, 1975 and *Electrical Times* (4334):2, 1975

CANADIAN STANDARDS FOR MICROWAVE OVENS

Radiation standards for MW ovens used in Canada have been amended as follows: where the generation of x-rays within a MW oven in excess of 2.5 mR/hr averaged over 10 cm² is possible while the oven is functioning in the prescribed manner, an x-irradiation warning sign that is clearly visible while the oven is being serviced must be permanently affixed to the MW power generating component. The leakage radiation at 5 cm from the oven, when fully assembled and operating at maximum output must not exceed: (1) 1.0 mW/cm² when the oven is loaded with the minimum operating load, and (2) 5.0 mW/cm² with no load for an oven with a total MW power generating capacity of less than 3 kW. The intensity of x-ray exposure 5 cm from the external surface must not exceed 0.5 mR/hr averaged over an area of 10 cm² when the oven is fully assembled and operating with its service and user controls adjusted to yield maximum output. *Int. Dig. Health Legis.* 26(1):59-60, 1975.

NO EMP EXPOSURE STANDARDS

In response to a 1972 request from the Boeing Company that safety standards for exposure to EMPs be set following guidelines set forth by the U.S. Air Force, a notice was placed in the *Federal Register*. This announcement requested information and advice on the

need for regulations, merits of the AF requirements, alternate suggestions, cost, environmental impact, injury and illness information, and other related information. The prevailing response was that the need for a standard at this time was doubtful and that data is insufficient to determine an appropriate maximum permissible exposure limit. No evidence of illness or injuries associated with EMPs was demonstrated. Therefore it was decided not to issue an EMP exposure standard at this time. *Federal Register*. 40(111):24579-24580, 1975.

TREATMENT FOR BURN SHOCK

V. P. Lapshin, B. N. Tkachenko, V. I. Shpakov, et al. have developed a method of correcting bioelectric activity of the brain under burn shock by using an alternating magnetic field of sine-curve form at fixed frequency to act on the brain. The form of the magnetic field is gradually changed from sine-curve (3-13 Hz frequency) to sawtooth (14-30 Hz frequency). The process continues until the basic rhythms are restored. A sine-curve magnetic field is then applied until a stable clinical effect is obtained and normal bioelectric activity is stably dominant on the EEG. *Soviet Inventions Illustrated* W(22):8, 1975

ARTERIAL ANEURISM TREATMENT METHOD

An arterial aneurism magnetic treatment method which uses a constant magnetic field to form a partial thrombus has been developed by R. P. Kikut and D. K. Miller of the Riga Traumatology and Orthopaedics Research Institute. To prevent complete blockage of the treated artery during thrombus formation the affected part of the artery is placed in a CMF. The vessel is filled with blood which is passed through the catheter inside which is a simulated saccular aneurism. The blood flow-rate is adjusted to 12 cm/sec and the catheter is then placed in the CMF (2500 Oe) which produces an EMF of 125 μ V perpendicular to the direction of flow for 0.5-1.5 hr. Thrombus formation is medically accelerated and clot formation is monitored. *Soviet Inventions Illustrated* W(20): 2-3, 1975

ITEMS FROM THE COMMERCE BUSINESS DAILY

O BEHAVIORAL AND ELECTROENCEPHALOGRAPHIC RESPONSES OF SQUIRREL MONKEYS EXPOSED IN UTERO TO 2450 MHZ ELECTROMAGNETIC RADIATION.

The Environmental Protection Agency, Research Triangle Park, North Carolina, has contracted with Stanford Research Institute, Menlo Park, California, for the above study. (July 8, 1975)

O MAINTENANCE OF A DATA BASE ON AVAILABLE LITERATURE PERTAINING TO BIOLOGICAL EFFECTS OF NON-IONIZED ELECTROMAGNETIC RADIATION.

NEWS ITEMS

*Biological Effects Electromagnetic
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The Office of Telecommunications Policy, Washington, D.C., has contracted with Mead Technology Laboratories, Dayton, Ohio, for the above study. (July 11, 1975)

o CONTINUATION OF ONGOING WORK IN THE STUDY OF THE BEHAVIORAL EFFECTS OF ANIMALS EXPOSED TO MICROWAVE RADIATION.

The Department of Health, Education, and Welfare, Rockville, Maryland, has contracted with Randomline, Inc., Huntingdon Valley, Pennsylvania, for the above study. (July 21, 1975)

o A FURTHER RESEARCH ON MICROWAVE RADIATION.

The Office of Naval Research, Arlington, Virginia, proposes to contract with Battelle Memorial Institute, Richland, Washington, for the above study. (August 13, 1975)

o STUDY OF THE EFFECTS OF A HIGH LEVEL OF EXPOSURE TO MICROWAVE RADIATION ON THE OFFSPRING OF MILITARY PERSONNEL.

The Department of Health, Education, and Welfare, Rockville, Maryland, has contracted with the American Health Foundation, New York, N. Y., for the above study. (July 3, 1975)

MEETINGS AND CONFERENCES

**** AMERICAN SOCIETY FOR NEUROCHEMISTRY

Date: March 9-14, 1975
Place: Mexico City, Mexico
Sponsor: American Society for Neurochemistry
Requests for Information: Dr. M. M. Rapport, N. Y.
State Psychiatric Institute, Div. of Neuroscience,
722 W. 168 St., New York, N.Y. 10032
Selected Bibliography of Papers Presented:
LEVELS OF GAMMA-AMINO BUTYRIC ACID IN MOUSE BRAIN FOLLOWING TISSUE FIXATION BY MICROWAVE IRRADIATION.
Knieriem (no affil.).
LABILE METABOLITE LEVELS IN RAT BRAIN AFTER RAPID TISSUE INACTIVATION WITH MICROWAVE IRRADIATION.
Medina (no affil.).
APPLICATION OF 300 mSEC MICROWAVE IRRADIATION FOR INACTIVATION OF CHOLINERGIC ENZYMES IN MOUSE BRAIN TO STUDY OF REGIONAL ACETYLCHOLINE LEVELS AND ITS DIFFERENTIAL MODIFICATION BY PENTOBARBITAL.
McCoy (no affil.).

**** IAEA SYMPOSIUM ON BIOLOGICAL EFFECTS OF LOW-LEVEL RADIATION PERTINENT TO PROTECTION OF MAN AND HIS ENVIRONMENT

Date: November 3-7, 1975
Place: Chicago, Illinois
Sponsor: International Atomic Energy Agency
Requests for Information: J. H. Kane, Office of Information Services, ERDA, Washington, D.C. 20545

**** MICROWAVE POWER SYMPOSIUM 1976

Date: July 27-30, 1976
Place: Leuven, Belgium
Sponsor: International Microwave Power Institute
Requests for Information: R. V. Decareau, P. O. Box 247, Amherst, New Hampshire 03037

**** IEEE INTERNATIONAL SYMPOSIUM ON ELECTROMAGNETIC COMPATIBILITY

Date: October 7-9, 1975
Place: San Antonio, Texas
Sponsor: IEEE
Requests for Information: W. E. Cory, Southwest Research Institute, Box 28510, San Antonio, Texas 78284

Selected Bibliography of Papers Presented:

HAZARDS: THE EFFECTS OF OPTICAL RADIATION ON BIOLOGICAL ENVIRONMENTS AND MATERIALS. W. T. Ham, Jr. (Med. Coll. Virginia, Richmond).

CALIBRATION OF A MULTIMODE MICROWAVE EXPOSURE CHAMBER. E. L. Bronaugh (Southwest Res. Inst., San Antonio, Tex.) and D. R. Kerns.

**** RADILOGICAL SOCIETY OF NORTH AMERICA

Date: November 30 - December 5, 1975
Place: Chicago, Illinois
Sponsor: Radiological Society of North America and American Association of Physicists in Medicine
Requests for Information: T. A. Tristan, M.D., Radiological Society of North America

BOOK NOTES

BIOLOGIC AND CLINICAL EFFECTS OF LOW-FREQUENCY MAGNETIC AND ELECTRIC FIELDS

by

J. G. Llaurado, A. Sances, Jr., and J. H. Battocletti

This book is the result of a symposium and workshop held in Aspen, Colorado in 1973 to examine the current state of knowledge on the effects of static and slow-changing magnetic and electric fields on the communication processes in all forms of life. The forum was designed to bring about collaborative efforts by engineers and life scientists to produce significant advances in the area of quantitative information regarding the effects of man-made EM emanations upon living organisms. The workshops included criteria and recommendations for a comprehensive research plan in the areas discussed applicable for research, industry, and government use. Pertinent chapters will be abstracted in the next issue of *Biological Effects of Electromagnetic Radiation*.

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 - II. Sources, Propagation, Amplitude and Temporal Variation of Extremely Low Frequency (0-100 Hz) Electromagnetic Fields
 - III. Critical Review of the Biological Effects of Electric and Magnetic Fields
 - IV. Electric and Magnetic Fields Produced by Commercial Power Systems
 - V. Psychological Effects of Magnetic and Electric Fields
2. SPECIAL TOPICS: SOURCES AND EFFECTS OF ELECTRIC AND MAGNETIC FIELDS ON BIOLOGICAL SYSTEMS
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 - XI. Communication in Bird Flocks: An Electromagnetic Model
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 - XXVI. Biological Effects of Electric Currents: Electrical Stimulation and Therapy
 - XXVII. Magnetics and Nuclear Magnetic Resonance

(Springfield: Charles C. Thomas, 1974), 345pp.

MAGNETISM AND ITS EFFECTS ON THE LIVING SYSTEM

by

A. R. Davis and W. C. Rawls, Jr.

Explanations of how magnetism affects the life of all living systems are found in this book, which deals with the two effects that are supplied by the two forms of energy transmitted from each pole of all magnets. The book is written without mathematical data to make it comprehensible to the layman as well as the student and scientist. A 34-item bibliography of general research references is included.

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Colors and Their Effects
Man's Biomagnetic Mind
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Warning
Measuring the Voltages of the Living System and Their Locations on the Body
Biomagnetic Biological Electronics
The Present and Future Research into Very High Gauss Magnetic Energies (VHG)
Conclusion

(Hicksville: Exposition Press, 1974), 132pp.

CURRENT LITERATURE

0551 SEARCH FOR EFFECTS OF 45 Hz MAGNETIC FIELDS ON LIVER TRIGLYCERIDES IN MICE. (E.) Beischer, D. E. (Naval Aerosp. Med. Res. Lab., Pensacola, Fla.) and R. J. Brehl. *Res. Rep. No. NAMRL-1197, 8p.*, 1975.

Eight-week-old female Charles River mice were exposed to an ELF electromagnetic field in a search for possible bioeffects of the field. One hundred forty mice were acclimated for 3 wk prior to exposure; seventy of these were randomly selected for exposure for 24 hr to a 45 Hz magnetic field with a field strength of 1 Oersted. Ten mice were decapitated immediately following exposure and 10 were randomly selected and sacrificed on each subsequent day. Livers were removed, prepared, and extracted with isopropanol for glycerides measurements. The 70 control mice were treated similarly. For all mice, body wt, liver wet wt and dry wt, and liver triglyceride content were measured. Water content of the liver and the ratio of liver to body wt were calculated. There were no significant differences between control and experimental animals for values determined during the time period studied. In this specific situation of short term exposure to low field strength EM energy, no effects of the field were observed. (1 reference)

0552 STIMULATION OF THE DEFENSES OF MICE WITH TRYpanosomiasis BY EXPOSURE TO RADIATION ASSOCIATED WITH A MAGNETIC FIELD AND ELECTROMAGNETIC WAVES. (Fr.) Fautrizel, R. (Lab. Parasite Immunol. Biol., Univ. Bordeaux II, France), A. Prioré, P. Mattern, and A. N. Pautrizel. *C. R. Acad. Sci. (Paris)* [D] 280(16):1915-1918, 1975.

Swiss mice were inoculated i.p. with 20,000 *Trypanosoma equiperdum* and, 48 or 72 hr later, were exposed to radiation associated with a magnetic field and electromagnetic waves for 6 hr/day for 6 days (no further details). Mice were irradiated the day after they had been inoculated with 100 trypanosomes and diffusion chambers had been implanted. One group received cyclophosphamide (70 mg/kg i.p.) the day before and the day after inoculation, while another group received a single i.p. injection of antigen immediately after the first session of therapy. Newborn mice from noninfected mothers were given 1000 trypanosomes s.c. on the day of their birth. Infected mice exposed to radiation 48 hr after inoculation had the same number of parasites in the blood as controls until 72 hr after infection. The number of parasites then decreased rapidly until, after 96 hr, none of these mice had parasites in the blood. Mice exposed to radiation 72 hr after inoculation were also freed of infection and survived, while all untreated controls died within 6 days after inoculation. All mice which recovered had a strong immune response (hemagglutinating antibody titers of 1:2000 or more) 8 days after inoculation, and only 2 of 22 had recurrences 15 days after radiation exposure was discontinued; these parasites, however, had different antigens than the ones the mice were originally inoculated with. Mice given cyclophosphamide and then exposed to radiation had no signs of parasitic in-

festation after 5 days of treatment, but all had recurrences, starting on day 12. Antibody titers in cyclophosphamide-treated mice were not as high as those in untreated mice 8 days after inoculation. No matter whether they were treated or not, newborn mice developed large numbers of parasites in their blood and died on day 6. Radiation increased antibody production in mice immunized with parasite antigen; 10 days after immunization, the titer was 1:16 in comparison to 1:2 in untreated mice. Radiation had no effect on the multiplication of trypanosomes placed in diffusion chambers. (6 references)

0553 THE EFFECT OF SIMULATED SFERICS (WEATHER-DEPENDENT ELECTROMAGNETIC RADIATION) ON PLATELET ADHESIVENESS. (Ger.) Jacobi, E. (2nd Med. Clin., Univ. Dusseldorf, Germany) and G. Krüskenper. *Inn. Med.* 2(2):73-81, 1975.

In an insulated steel chamber with controlled temperature and humidity, 115 volunteers were subjected to simulated sferics at a pulse intensity of 0.4 V/m and a carrier frequency of 10 kHz; 30 volunteers subjected to an electric zero level served as controls. In most cases, exposure times were 3 hr. The simulated sferics had PRFs which ranged from 2 to 20 Hz. *In vitro* measurements of platelet adhesiveness were made before and after exposure. Platelet adhesiveness was increased at a PRF of 10 Hz, but was decreased at electric zero levels and at 2, 5, and 20 Hz. A PRF of 10 Hz reduced the decrease in platelet adhesiveness induced by the electric zero climate. No differences in platelet adhesiveness were found in subjects exposed to pulse intensities of 0.2 V/m and those exposed to 0.4 V/m. Double blind studies were performed on 40 additional volunteers to determine whether drugs which reduce platelet adhesiveness have any effect on sferic-induced increases. These 40 subjects were divided into 4 groups of 10 subjects each. These groups received orally: (1) a placebo; (2) 75 mg of dipyridamole; (3) 300 mg of acetylsalicylic acid; and (4) 75 mg of dipyridamole + 300 mg of acetylsalicylic acid. Sferic-induced increases in platelet adhesiveness were suppressed only by the combination of both drugs. Subjects with an increased tendency to exhibit psychasthenic insecurity, as determined by the Minnesota Multiphasic Personality Inventory, tended to show the greatest sferic-induced responses in platelet adhesiveness, while those with high scores on the lying scale showed no changes. Although these studies do not demonstrate a causal relationship between sferics and increased platelet adhesiveness resulting in thrombosis, such a relationship may exist, particularly if some other predisposing factors are present. (18 references)

0554 LOW ENERGY ELECTROMAGNETIC PERTURBATION OF AN ENZYME SUBSTRATE. (E.) Goodwin, B. C. (Sch. Biol. Sci., Univ. Sussex, Brighton, England) and S. Vieru. *Physiol. Chem. Phys.* 7(1):89-90, 1975.

Irradiation of enzyme substrates in crystalline form

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with light from either a mercury or tungsten lamp at particular radiation time intervals causes an increase in the initial velocity of the enzyme catalyzed reaction. Aliquots of urease were evaporated to dryness and irradiated for 0, 20, 25, or 30 sec with light from a high-pressure Hg lamp. Urease activity was measured by a modified Nessler procedure. Previous experiments had shown that crystals irradiated for 25, 55, 85, 115, 145, and 175 sec showed increased reaction velocity. A significant increase in the reaction velocity (0.255 mean OD/5 min reaction time) was observed only after the 25 sec irradiation, with other radiation times giving no detectable response (0.236, 0.234, and 0.235 mean OD/5 min for 0, 20, and 30 sec, resp.). Preliminary experiments have also confirmed the effect with glucose-6-phosphate dehydrogenase and a yeast auxotroph. (7 references)

0555 ENVIRONMENTALLY CONTROLLED WAVEGUIDE IR-RADIATION FACILITY. (E.) Ho, H. S. (HEW, PHS, BRH, Rockville, Md.), E. I. Ginnis, and C. L. Christman. 1973 IEEE-G-MTT Int. Microwave Symp., 255-256, 1973.

An environmentally controlled MW waveguide irradiation facility has been developed to irradiate small animals in such a manner that the integral dose and integral dose rate can be determined. The chamber surrounding the waveguide permits temperature and relative humidity control by drawing conditioned air through the waveguide at controlled flow rates. The integral dose is determined without significant perturbation of the field interacting with the animal and the integral dose rate can also be continuously recorded. The generator provides up to 100 W of CW power at 2450 MHz. The WR 430 waveguide is designed to operate at TE₁₀ mode from 1.7 to 2.6 GHz. The forward, reflected and transmitted power can be measured with calorimetric power meters. The animal is contained in a thin holder of low loss dielectric material and loss due to the waveguide walls and holder are negligible. As the integral dose rate varies with movement of the animal, stages of stress can be quantitatively determined by monitoring reflected and transmitted power. Techniques such as thermographic cameras and miniaturized MW diode probes are also being explored since the spacial distribution of absorbed MW energy is non-uniform. (10 references)

0556 BRAIN FREE FATTY ACID LEVELS IN RATS SACRIFICED BY DECAPITATION VERSUS FOCUSED MICROWAVE IRRADIATION. (E.) Cenedella, R. J. (Inst. Pharmacol. Pharmacognosy, Univ. Milan, Italy), C. Galli, and R. Paoletti. *Lipids* 10(5):290-293, 1975.

Although cerebral free fatty acids (FFA) influence enzymatic processes of the brain to a large extent, reported concentrations vary widely. This is due to a rapid increase in brain FFA occurring within a few min after sacrifice, presumably because of normal enzymatic activities. Male Sprague-Dawley rats were

sacrificed by decapitation or a 3 sec exposure to a focused MW beam and FFA content was measured colorimetrically. Following decapitation or irradiation, the brains were either removed immediately or allowed to remain in situ at room temperature for 5 min. They were frozen in liquid N₂ within 60 sec after removal. The brains were weighed, homogenized, extracted and recovered on TLC. The extracts contained 100-180 mg total lipid. The concentration of FFA in brain samples frozen immediately after sacrifice was ~0.3 µM/g wet wt (90 µg/g) after decapitation or irradiation. Brains removed 5 min after decapitation contained >100% more FFA than those removed immediately, with a disproportionate increase in arachidonic acid content. There was no increase in animals sacrificed by focused MW irradiation. Thus, focused MW irradiation appears to be a superior method for quantitating heat stable components of brain which are generated rapidly or catabolized during post mortem processes. Total rat brain enzyme deactivation occurs within 3 sec of exposure. (13 references)

0557 ELECTROMAGNETIC SIGNALS IN LIVING NATURE: FACTS, HYPOTHESES, DIRECTIONS OF RESEARCH. (E.) Presman, A. S. (no affil.). (Moscow: Soviet Radio Publishers, 1974), trans. for JPRS, No. 64228, 53p., 1975.

This book reviews the data and theory on the interaction between EM signals and living matter. The diversity of organisms on earth evolved due to continuous interaction with environmental factors including the various components of the EM spectrum, from γ-radiation to frequency changes in geomagnetic and geoelectric fields. Many organisms are found to have a high sensitivity to EMFs with parameters close to those of natural fields. These biological effects which cannot be explained by energy relationships may stem from information interactions of EMFs with the cybernetic systems of the organism which perceive the information from the environment and regulate its vital processes. The advantages of EMFs as compared to sound, light, etc., are fourfold: (1) LF EMFs can penetrate all environments inhabited by organisms; (2) information can be transmitted by EMFs over any distances and under any meteorological conditions; (3) periodical changes in meteorological factors appear to be coordinated with corresponding changes in natural EMFs and (4) solar flares are always accompanied by 'flash-ups' in EMFs. Biologists tend to study EMR as it affects biological organisms at all levels of the hierarchy of living organisms while engineers and physicists are interested in specific mechanisms of EM signaling in living nature so corresponding technical devices can be modeled. Success will be achieved when all scientists develop a single viewpoint and common approach to their solution. (101 references)

0558 RESPONSES OF THE MOUSE TO MICROWAVE RADIATION DURING ESTROUS CYCLE AND PREGNANCY. (E.) Rugh, R. (HEW, PHS, BRH, Div. Biol. Eff., Rock-

ville, Md.), E. I. Ginns, H. S. Ho, and W. M. Leach. *Radiat. Res.* 62(2):225-241, 1975.

A radiation facility was developed in which animals could be exposed in a temperature and humidity controlled environment and both integral dose and integral dose rate could be calculated. Mature, 25-35 g, CFL white mice were exposed individually to 2450 MHz MW radiation in this waveguide. Seventy-seven males were irradiated, plus 164 females in various stages of estrus and 855 litters. After determining the stage of estrus from a vaginal smear, females were acclimated in the environmental chamber for 20 min and irradiated during a 4 hr period. Those in diestrus showed an absorbed lethal dose of 11.50 cal/g body mass while the absorbed lethal dose for estrus was 10.65 cal/g. The mean lethal absorbed dose was significantly greater ($p < 0.01$) during diestrus than during estrus, indicating a true differential sensitivity of the female to MW radiation during the estrous cycle. This may be due to a slight increase in tissue hydration or a hormone-dependent change in radiosensitivity. Females were time mated for fetal studies so that they were irradiated at the 8.0 day gestation stage, as this day is particularly sensitive to ionizing radiation. Pregnancies were terminated at 18 days and litters were examined for abnormalities including exencephalies, resorptions, dead fetuses, and stunting. The most frequent abnormality was exencephaly (brain hernia). The mice were irradiated with a forward power of 7.37 W at 25°C and 50% relative humidity and variable exposure times up to 5 min. The average absorbed dose was 3-8 cal/g. In studies on male mice the average lethal dose was 12 cal/g at 6.94 W forward power, with radiation continuing until death. Normal litters and anomalous fetuses were observed throughout the range of average MW exposures used. However, the number of litters without anomalous fetuses decreased as the average absorbed dose increased, suggesting the possibility of a dose-effect relationship. The maximum production of anomalies by MW radiation involved ~60% of a single litter and the average frequency of exencephaly at 8 cal/g was ~12%. There is no direct correlation between dose and anomaly production, but with increased doses there is an increased probability that the litter will have at least one anomalous fetus. (9 references)

0559 PERCUTANEOUS RADIOfREQUENCY ELECTROCOAGULATION IN THE CONTROL OF CHRONIC PAIN.
(E.) Pawl, R. P. (Abraham Lincoln Sch. Med., Univ. Illinois, Chicago). *Surg. Clin. North Am.* 55(1):167-179, 1975.

Electrocoagulation of sensory pathways using RF currents is used as a treatment mode for pain control. With ready access to RF currents, insulated electrodes thin enough to pass through spinal needles, and temperature monitoring devices to permit controlled coagulation of neural tissues, this technique often gives relief of pain without permanent sensory loss in a relatively large body area. Neurosurgeons are piercing pain pathways percutaneously in places where scaples were previously utilized. Three methods are

described in this article which are very simple: Gasserian ganglion coagulation, lumbar facet denervation, and dorsal root ganglion coagulation. Necessary equipment for each of these includes x-ray, a radio frequency generator, an electrical stimulator, and a variety of electrodes. Pinpoint placement of small electrode tips in the neural pathway of specific trigger regions often results in preservation of most sensory modalities while relieving serious sensory symptoms. Further work is needed to perfect this technique in the areas currently treated and to expand to treatment of other pain syndromes. (20 references)

0560 HEAT IN MALE CONTRACEPTION (HOT WATER 60°C, INFRARED, MICROWAVE, AND ULTRASOUND). (E.) Fahim, M. S. (Dep. Obstet. Gynecol., Univ. Missouri, Columbia), Z. Fahim, R. Der, D. G. Hall, and J. Harman. *Contraception* 11(5):549-563, 1975.

Normally the scrotal testis of mammals is 3-4°C below that of the body core. The effect of heat in suppressing spermatogenesis without altering Leydig cell secretion has been investigated. Three hundred male Sesco rats (250-300 g) were divided into control and 9 different treatment groups. Following treatment and progeny tests, 10 rats from each group were sacrificed at 10 days and 60 days. The remaining 10 males were mated regularly for 10 mon and sacrificed. The rats were divided as follows: (1) controls; (2) testes exposed to a 60°C water bath for 15 min; (3) testicular temperature raised to 60°C for 15 min with an IR heater; (4) testes radiated at 2450 MHz for 5 min, with testicular temperature raised to 65°C; (5, 6, 7) MW radiation at 20 W for 1 min (39°C final temperature), 5 min (39°C), and 15 min (45°C final temperature, resp.); (8, 9, 10) US exposure at 1 W/cm² for 5 min, two 5 min exposures at 1 W/cm², and exposure at 2 W/cm² for 5 min. All animals were mated with proestrus females 24 hr after treatment and each 5 days following until pregnancy was documented to have occurred. The fertility endpoint was the amount of time for every surviving male in each group to impregnate a female. For group 2, females were found impregnated 30-35 days after male treatment. Group 3 animals were fertile 60-75 days after IR application. MW radiation at 100 W resulted in infertility over the entire 10 mon period. Treatment in group 5 was ineffective; those in group 6 impregnated females after 65-80 days; and group 7 were infertile 10 mon after treatment. When US was applied, females were impregnated 150-210 days after male treatment with 1 W/cm², but no females conceived after 10 mon when the dose was doubled and when 1 W/cm² was applied twice. No significant changes were noted in sex organ wt during the test period and no change of blood testosterone levels was noted. Intracellular penetration of heat was more effective by MW radiation than water or IR treatment. Duration of treatment was an important factor, as noted in MW and US treatment. US was more effective than MWs at a lower temperature because of the combined effects of heat and mechanics. No pain was observed in US treated animals when they were awake. No abortions were noted among females and pups were similar to controls. (12 references)

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0561 EFFICACY OF PULSE UHF, DECI-METER AND CENTI-METER WAVELENGTH THERAPY IN PATIENTS WITH CERVICO-THORACIC OSTEOCHONDROSIS AND CONCOMITANT ISCHEMIC HEART DISEASE. (Rus.) Sorokina, E. I. (Centr. Inst. Health Resorts Physiother., Moscow, USSR) and A. I. Krupennikov. *Ter. Arkh.* 47(1):104-105, 1975.

Studies of 148 patients with cervico-thoracic osteochondrosis and concomitant atherosclerotic cardiovascular or stenocardia were conducted. They were treated with pulsed UHF therapy (40 patients) with flexible plates (5-6 kW, pulse length 2 sec), and with decimeter (57 patients) and centimeter (6 patients) wavelength therapy with rectangular plates (30-40 W for 10 min). The results of the treatment indicated that exposure to pulsed UHF and decimeter range radiation had a beneficial effect on the function of the ventricular myocardium while treatment by centimeter irradiation either had no effect or had an adverse effect on five patients with stenocardia. Pulsed UHF therapy was particularly effective in lowering high arterial pressure. After 10-15 sessions, significant improvement was observed in 12, improvement in 20 and no change in 8 patients treated by pulsed UHF therapy. The results for decimeter and centimeter therapy were: 21, 29, 7 and 10, 28, 11, resp. The condition of 7 patients exposed to centimeter radiation deteriorated. The followup from 6 to 24 mon showed a stable therapeutic effect in most of the patients after pulsed UHF and decimeter therapy and in nearly half of the patients treated by centimeter wavelength radiation. (No references)

0562 ACTION OF ELECTROMAGNETIC FIELDS OF SUPER-HIGH FREQUENCIES ON ERYTHROCYTES PRESERVED AT LOW TEMPERATURE. (Rus.) Zalyubovskaya, N. P. (Inst. Cryog. Biol. Med., Kiev, USSR), O. I. Gordienko, and R. I. Kiselev. *Probl. Gematol. Pereliv. Krov.* 20(4):31-33, 1975.

Studies were made of the effects of 5-8 mm SHF radiation at 1 mW/cm² on erythrocytes prior to their freezing in polyethelene oxide. No significant morphological changes were observed in exposed erythrocytes. Free hemoglobin content in erythrocytes after freezing and thawing decreased to 300 mg% at 6.50 mm exposure. Erythrocytes exposed prior to freezing appeared to be more resistant to the lytic action of HCl. The maximum destruction of erythrocytes (50%) occurred after 3.5 min of the hemolytic action, while complete hemolysis was observed after 5 to 6 min. Unexposed controls showed the highest erythrocyte destruction (72%) within 1.5-2.5 min with complete hemolysis occurring in four min. Exposed erythrocytes also exhibited greater resistance to NaCl after thawing; the content of hemolysed erythrocytes in 0.48% NaCl was 60%; for unexposed cells, 80% in 0.52% NaCl. No effect of 6.5 mm exposure was observed on hemoglobin mobility and composition in the erythrocytes after freezing. It is suggested that SHF exposure of erythrocytes prior to polyethelene oxide freezing enhances their resistivity to low temperatures. (1 reference)

0563 THE EFFECT OF ELECTROMAGNETIC FIELDS ON THE COAGULABILITY OF BLOOD. (Rus.) Rusaev, V. F. (Chita Med. Inst., USSR), and Mulindina, G. I. *Gig. Sanit.* (4):107-108, 1975.

Studies were carried out of the effects of UHF electromagnetic fields on coagulability and fibrinolytic characteristics of the blood and cardiovascular tissues. Mice were exposed to 40 MHz for 15 min at 80 V/m or to the static electrical field for 15 minutes at 330 V/cm perpendicular to the earth's surface. The findings indicated that exposure to UHF radiation inhibited the thromboplastic and fibrinolytic activity of the tissues contributing to hypercoagulability. It is suggested that the changes in the EM environment may result in disrupted cellular membrane structures containing protein-bound phospholipids. The breakage of bonds between phosphatidylcholine, phosphatidylserine and phosphatidylethanolamine, known for their powerful thromboplastic action, may result in their liberation from the cell and subsequent massive pouring into the blood stream. The decrease in the thromboplastic activity of the tissues was accompanied by hypercoagulability. (8 references)

0564 THE RATIONALE FOR AND EXPERIENCE IN THE APPLICATION OF ELECTROMAGNETIC STIMULATION IN THE SURGICAL THERAPY OF BONE FRACTURES AND FALSE JOINTS. (Rus.) Tkachenko, S. S. (S. M. Kirov Mil. Med. Acad., Leningrad, USSR), and V. V. Rutzky. *Ortop. Traumatol. Protez.* (1):1-6, 1975.

Experimental studies of the effect of EM stimulation of osteosynthesis in 92 patients with bone fractures and false joints showed a correlation between the reparative regeneration of the bone tissue and the nature and regimen of EM exposure. Osteosynthesis was carried out by the use of metal screws, plates, spikes, etc. in 55 patients; ultrasound adhesive technique in 9 patients; and transosseous osteosynthesis in 28 patients. Electromagnetic stimulation involved the use of a portable electronic device connected with the metal electrodes sunk into the bone tissue, or implanting the conductor in the bone bed prepared for polymer joining. The results showed that after 7-10 days of EM action there were signs of callous formation, while 2-3 weeks later, x-ray examination showed the formation of regenerative bone tissue around the electrodes. The follow-up of 3-24 mon showed that the joining of the bone fragments was significantly faster in patients treated by EM stimulation. (No references)

0565 APPLICATION OF NONTHERMAL EFFECTS IN HIGH DIELECTRIC MATERIALS TO MICROWAVE DOSIMETRY. (E.) Vetter, R. J. (Bionucl. Dep., Purdue Univ., West Lafayette, Ind.), D. R. Elle, D. J. Fehringer, and P. L. Ziemer. 1973 IEEE-G-MTT Int. Microwave Symp. 260-261, 1973.

Dosimetry is one of the most pressing problems in research on the effects of MWS. A study was designed

to examine the thermoluminescent response of high dielectric inorganic materials before and after MW irradiation. In addition, activation and thermoluminescent characteristic studies of the materials were designed and the materials were examined for a change in thermal stimulated exo-electron emission (TSEE) after MW exposure. The materials studied were powdered or ceramic samples of phosphors of the perovskite class, including BaTiO_3 activated with various concentrations of Dysprosium and $(\text{BaSr})\text{TiO}_3$ with various ratios of Ba to Sr. Control samples were run by heating in an oven to the maximum temperature reached during MW exposure. The reduction in thermoluminescent response of the $(\text{Ba}_{0.8}\text{Sr}_{0.2})\text{TiO}_3$ phosphor was significantly greater than that of the thermal control as was the response of the activated phosphors BaTiO_3 containing 0, 0.1, and 0.5 mole percent Dy. This fading is considered nonthermal since it was greater than an oven heated control. It may provide a method to determine MW absorbed energy. The reduction in TSEE was due to thermal buildup and would have little or no use in MW dosimetry. (9 references)

0566 BIRD FEATHERS AS DIELECTRIC RECEPATORS OF RF FIELDS. (E.) Bigu del Blanco, J. (Dep. Anat., Queen's Univ., Kingston, Ontario, Canada), C. Romero-Sierra, and J. A. Tanner. 1973 IEEE-G-MTT Int. Microwave Symp. 268-270, 1973.

Feathers have a fundamental role in the life and survival of birds. In birds exposed to MW radiation, they may act as selective sensors of the surrounding medium. Their characteristics as dielectric aerials were investigated in experiments conducted with the calamus of bird feathers at about 10 GHz. Radiation pattern measurements were made with and without the feather in place and with single feathers and an array of three feathers about $\lambda_g/2$ distant from each other (λ_g is the waveguide wavelength). When the feather is in place an increase in the power received in the forward direction and a decrease in the beamwidth occurs. The increase is larger for the array of feathers than for the single feather. The effects are probably due to a combined guiding and focusing effect on the MW field by the feather. If a similar effect takes place in the bird, an increase in the MW field strength should be sensed by the bird. The sensory mechanism probably involves the feather as a receptor of the incoming signal. (8 references)

0567 THE EFFECT OF A SINGLE DOSE OF LETHAL AND NON-LETHAL SUPER HIGH FREQUENCY RADIATION ON DIFFERENT NEURONAL FORMATIONS IN THE BRAIN. (Rus.) Galkina, N. S. (Riazan Med. Inst., USSR) Zh. Nevropatol. im S. S. Korsakova 5(2):223-229, 1975.

Experiments were performed on albino male rats exposed to SHF radiation at a power density of 150 mW/cm^2 for 10 min (group 1) and 5 min (group 2) to study the effect on cerebral neurons. All the animals in group 1 died during the exposure; the animals from group 2 survived and were decapitated within 1-30 days to study the residual effect of the exposure on the brain. Histological studies showed acute venous hypervolemia,

arteriostenosis and large cerebral hemorrhages. The findings indicated that exposure to SHF radiation of medium density resulted in cerebral hypoxia causing destructive changes in the cerebral neurons, including neuronal swelling accompanied by tigrolysis, hypochromatosis, decrease in the RNA content, and dehydration of the neurons which persisted after the exposure. The most intensive damage was observed in Betz cells, the neurons of the large hippocampus, the optic thalamus and afferent reticular neurons. Certain adaptive and compensatory reactions in the survivors were observed during the month after the exposure. (19 references)

0568 PROLIFERATION OF ELECTROMAGNETIC POLLUTION; OR LOOK WHAT WE'RE DOING TO OURSELVES! (E.) Lynn, J. F. (no affil.) 1974 IEEE Electromagn. Compat. Symp. Rec., 41-49, 1974.

The use of EMR began with broadcast radiation around 1900 and is now being used in ever increasing amounts with a continuous increase in the quantity and kind of device producing the radiation. Man-made sources of EM pollution have increased about 20% each year for the last 35 years, creating conditions from minor annoyances to catastrophic failures of complex systems. Technology is rapidly outdistancing the regulation of EMR. Among those devices emitting are telephones, TVs, cable TV, MW ovens, land mobile equipment, office automation, household appliances and gadgets, auto electronics, lasers, and industrial and defense products. New and revised standards, measurement techniques, and instrumentation should be expected. (14 references)

0569 THE EFFECT OF CONTINUOUS AND PULSED UHF ELECTRIC FIELDS ON THE METABOLISM OF SEROTONIN IN PATIENTS WITH PEPTIC ULCER. (Rus.) Komissarova, I. V. (Cent. Inst. Health Resorts Physio-ther., Moscow, USSR) Vopr. Kurortol. Fizioter. Lech. Fiz. Kult. (2):170-174, 1975.

Studies were carried out on 76 patients with peptic ulcer treated by UHF therapy in pulsed (2 usec) and continuous regimens. The patients received treatment every other day for 8-10 min (PW) or 6-12 min (CW) during 10-12 sessions. The findings indicate that exposure to continuous UHF irradiation stimulated serotonin synthesis in the duodenum and increased its secretion with gastric juices. Pulsed UHF exposure tended to reduce serotonin content in the blood and gastric juices. It is suggested that the different effect of the CW and PW radiation may be accounted for by the absence of thermal action in UHF pulsed regimen. (12 references)

0570 THE EFFECT OF ULTRA HIGH FREQUENCY ELECTRIC FIELD ON SPERMATOGENESIS IN PATIENTS WITH EPIDIDYMITS. (Rus.) Grachev, Y. I. (Cent. Inst. Skin, Vener. Dis., Moscow, USSR) and G. A. Voskresenskaya. Vestn. Dermatol. Venerol. (2):75-79, 1975.

The effect of UHF electric field on spermatogenesis was studied in 19 patients with gonorrhreal and non-

gonorrhreal epididymitis 20-25 days after the exposure of the patients' testes to two disk plates emitting 39-40 million oscillations per sec (generator power 40 W). The treatment consisted of ten 10 min daily sessions. The microscopic examination of the seminal fluid showed no detrimental effect on spermatozoa. Comparison with the results obtained in the control group of patients treated by autohemotherapy failed to reveal any significant difference in the morphological composition of the seminal fluid or the motility of spermatozoa. (15 references)

0571 BLINDNESS, DEAFNESS AND VESTIBULAR DYSFUNCTION IN A MICROWAVE WORKER. (E.) Zaret, M. M. (no affil.) *Eye, Ear, Nose, Throat Mon.* 54(7):291-294, 1975.

An unusual case of bilateral blindness, bilateral deafness and bilateral vestibular dysfunction was presented. The patient, a 53-year-old radar repairman, worked as a MW troubleshooter for 27 yr. During this time no meaningful control was exercised over his environmental exposures. He was found to be in excellent health in independent examinations in 1942, 1944, and 1948. In 1949 he was involved in an accidental exposure to intense MW energy at less than 2 ft. A few hr later he became dizzy and lost hearing in his right ear. The dizziness disappeared after several days, but the hearing loss in his right ear became complete irreversible deafness within 2 wk. He also developed dysfunction of the vestibular apparatus of his right ear. The patient gradually developed recurring keratitis, recurring chorioretinitis resulting in retinal perivasculitis, retinitis proliferans and vitreous hemorrhages, and secondary glaucoma intractable to treatment which ultimately included multiple surgical procedures. In March, 1970, the patient became blind bilaterally and shortly thereafter became deaf in his left ear. As none of his findings fit any previously known medical disease or syndrome, the implication of MW irradiation etiology was logical and prudent. Otologic examination concluded that there was a total loss of hearing and substantial loss of vestibular function in both ears probably secondary to MW exposure. On ophthalmic examination, no useful visual acuity was present in either eye. Repeated differential diagnostic examinations by various physicians excluded all possible known causes for each finding other than MW irradiation. (No references)

0572 MICROWAVE PASTEURIZATION OF MILK. (E.) Jaynes, H. O. (Dep. Food Technol. Sci., Univ. Tennessee, Knoxville) *J. Milk Food Technol.* 38(7):386-387, 1975.

The pasteurization of milk with a MW energy source was studied in a system mechanically resembling conventional equipment in the heating-holding-cooling sequence of operations. MW energy at 2450 MHz was applied through a rectangular brass waveguide enclosing a Teflon flow-through liquid applicator. A regenerator was used to warm incoming cold milk and cool milk after heating. The milk was heated to 72 C for 15 sec and compared to controls treated at 62.8 C for

30 min. The phosphatase test, standard plate and coliform count, and taste were compared. Milk was pasteurized at 200, 300, and 400 ml/min. In all instances the phosphatase tests were negative and comparable count reductions were found at all 3 flow rates. A taste panel found MW treated milk to be equal or superior to conventionally handled milk. MW energy may be used as an alternate heat source for continuous pasteurization of milk and could be financially feasible in a situation in which atmospheric pollution should be minimized. (6 references)

0573 OBSERVATIONAL EVIDENCE THAT SHORTWAVE RADIATION GIVES ORIENTATION TO VARIOUS INSECTS MOVING ACROSS HARD-SURFACE ROADS. (E.) Gunter, G. (Gulf Coast Res. Lab., Ocean Springs, Miss.) *Am. Nat.* 109(965):104-107, 1975.

The relationship of various insects to hard surface roads which form part of the environment over much of the earth has been observed. The salt-marsh caterpillar, the larva of the moth *Estigmene acrea*, always goes straight across the road no matter what direction the road runs. On curves, they bisect a symmetrical pattern of the road. At the edge the caterpillar resumes a meandering path. The rove beetle *Staphylinidae* and the beetle *Pasimachus* cross in the same manner. Butterflies singly and in large groups fly straight across the road. A common southern Texas grasshopper spends the night on paved roads in the fall in search of warmth. All the grasshoppers are turned by morning so the long axis of their bodies was perpendicular to the long axis of the road. They thus present a symmetrical placement with respect to the radiant energy coming from the road. All these insects balance themselves with respect to a symmetrical source of SW radiant energy outside the range of light. They cross hard surface roads by the shortest possible route in a tropistic response to the symmetry of radiant energy coming from the road. This response has survival value for insects as they cross bare spots of the earth in the shortest possible time. (4 references)

0574 THE OTP/OT SPECTRUM MANAGEMENT PROGRAM - AN OVERVIEW. (E.) Dean, W. (OTP, Executive Off. Pres., Washington, D.C.) and S. I. Cohn 1974 *IEEE Electromagn. Compat. Symp. Rec.* 110-112, 1974.

The Radio Spectrum is a reusable vital national resource. The Federal Government has exclusive use of 25% of the spectrum and shares 45% with non-government users. The responsibility for management of the Government's use of the spectrum is assigned to OTP. The goal of management is to make efficient and effective use of this resource. Presently the Federal Government has more than 120,000 frequency assignments which change at the rate of 5000 per mon. OTP's spectrum management program concentrates on 6 areas: Policies, Allocation and Management, Analysis of Specific Impact of Communications - Electronic Systems, Requirements and Assignments, Compliance and Side Effects (both biological and nonbiological). (No references)

0575 THE EFFECTS OF AN ELECTRIC FIELD ON SOLUBLE COLLAGEN. (E.) Kahn, L. D. (U.S. Dep. Agric., Philadelphia, Pa.) and L. P. Witnauer. *Biochim. Biophys. Acta* 393(1):247-252, 1975.

The presence of an electric field induces changes in the permanent dipole moment and electric susceptibility of collagen. In this study, electric birefringence in a single pulsed field was measured as functions of pulse width and amplitude, and samples were subjected to trains of pulses to investigate the effect of repeated application of an electric field. The electric birefringence decay curves were resolved into 2 components: one was assigned the rotary diffusion coefficient of collagen monomer and the other was assumed to be an average for all aggregated collagen species present; it served as a measure of the extent of aggregation. The collagen was from fresh calfskin corium. The shape of the curve of D_B , the average rotary diffusion coefficient for aggregated collagen at constant pulse amplitude vs pulse width, was typical of all soluble collagen preparations with plateau values indicating that the range of aggregate stays within definite limits. A progressive decrease in D_B with increasing pulse width indicates that either the electric field is inducing aggregation or there is an ES interaction between neighboring particles. It was determined that particle interaction takes place only at lower values of ionic strength. At low pulse widths, monomeric collagen makes a large contribution to the electric birefringence, but at higher pulse widths the aggregate species account for a greater portion, a natural consequence of a population of aggregates being built at the expense of monomeric units. On repeatedly pulsing a dissolved collagen preparation, electric birefringence increases with each succeeding pulse until a maximum is reached. Thus, the presence of an electric field promotes aggregation of collagen particles suspended in an aqueous buffered medium. In fields of short duration the aggregate is of a transient nature, but the bonds become progressively stronger as field strength and duration increase. The bonds are probably of an ES nature. (4 references)

0576 EFFECT OF MAGNETIC FIELD ON OSCILLATING BLOOD FLOW IN ARTERIES. (E.) Sud, V. K. (Dep. Biophys., All India Inst. Med. Sci., New Delhi), P. K. Suri, and R. K. Mishra. *Stud. Biophys.* 46(3): 163-171, 1974.

Magnetohydrodynamics is the study of the motion of an electrically conducting fluid in the presence of EMFs. If the moving magnetic field is applied to a tube flowing with electrically conducting fluid in such a way that the speed of the field is more than that of the moving fluid, the rate of movement of the fluid will be accelerated, and vice versa. Since blood is an electric conductor, it seems possible to regulate its movement by the application of a magnetic field. In the mathematical model an artery is replaced by a long rigid tube of uniform diameter. The flowing liquid blood is considered as a Newtonian, viscous, incompressible, homogeneous and electrically conducting fluid. The constant applied magnetic field B_0 is along the radial r -direction. The following assumptions are made regarding the EM interaction: (1) the

induced magnetic field and the electric field produced by the motion of the electrically conducting fluid are negligible; and (2) no external electric field is applied. The results indicate that the effect of the uniform stationary magnetic field is to slow down the movement of blood. (5 references)

0577 ORIENTATION OF GULL CHICKS EXPOSED TO PROJECT SANGUINE'S ELECTROMAGNETIC FIELD. (E.) Southern, W. E. (Dep. Biol. Sci., Northern Illinois Univ., DeKalb). *Science* 189(4197):143-145, 1975.

It is possible that factors which interfere with the magnetic environment of a bird may disrupt its orientation. Tests were conducted at the Wisconsin Test Facility of Project Sanguine to determine whether man-made structures which generate high intensity EMFs have similar effects. The Sanguine System will use ELF waves to communicate with the submarine fleet. The experiments were designed to test effects of frequency, current, and mode of transmission. The test antenna was operated at 45 or 76 Hz and 260 or 300 amp. Groups of sixty 3-to-9-day-old ring-billed gull chicks were used for 2-3 days each and were maintained at a site of minimal effects from Sanguine, reducing the possibility of acclimation. Controls were tested when the system was not energized. Data were obtained on clear days so the sun would be available as a supplemental guide for orientation. Previously tested chicks had shown significant directional preference for southeast, as did control gulls. The 642 birds tested under experimental conditions had no significant mean bearing indicating a random dispersion in the test apparatus. Thus, the EM field encountered at ground level is sufficient to disrupt their orientation. Further tests are required to show if this observation holds true at various distances from the antenna. Since the magnetic field decreases rapidly as distance increases, birds migrating over Sanguine might pass unaffected. (16 references)

0578 CATCH SELECTIVITY BY ELECTRICAL FISHING SYSTEMS. (E.) Stewart, P. A. M. (Mar. Lab., Aberdeen AB9 8DB, Scotland). *J. Cons. Int. Explor. Mer.* 36(2):106-109, 1975.

Experiments have shown that large fish react to uniform electric fields at lower field strengths than small fish. A linear relationship exists between fish length and voltage along the fish. Therefore, a fishing system which incorporates an electric stimulus should preferentially capture the larger members of a fish stock. Electrotaxis and electronarcosis can also be used to aid capture. Selectivity is the probability, expressed as a function of fish length, of reactions being induced in fish within the electric field. The fraction of the electrified region in which the field strength is greater than the threshold level for a given size of fish represents the probability of a reaction being induced in that size fish. Electric fishing systems can act with imperfect selectivity, with a compromise being reached between efficiency in capturing large fish and inefficiency in capturing small fish. The voltage and separation can be chosen

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to give a probability-length curve which reaches 100% at the maximum fish size. The size selectivity can be calculated if the relationship between threshold strength and fish length is known for that species and if the path of the fish throughout the system is known so that the appropriate electric field distribution can be obtained. (7 references)

0579 THE DEVELOPMENT OF A NEW METHOD OF HEPATECTOMY BY RADIATION OF MICROWAVES. (E.)
Osaka, A. (Dep. Int. Med., Sapporo City Hosp., Japan).
Bull. Soc. Int. Chir. 33(3):166-171, 1974.

The ability of MWs to coagulate protein rapidly was utilized in a procedure for the resection of the liver. The livers of 25 rats and 25 rabbits were irradiated with 2450 MHz and an output power of 550 W. Protective jackets were made for the animals to protect the body from irradiation. A hole in the jacket allowed the lobe of the liver to be inserted. The liver was exposed for 1.5 min in rats and 3-4 min in rabbits. There was no bleeding or cholerrhagia from the cut surface of the liver following resection, and disinfection was unnecessary as the lobe was sterilized with MWs. Resection of 50% of the liver was possible with the radiation apparatus used. With a suitable jacket designed, 75-80% of the liver could be resected. All liver function tests were normal within a week. The animals survived well without anemia or hypoproteinemia. (No references)

0580 MEASUREMENTS FOR RADIATION SAFETY. (E.)
Wyckoff, J. M. (NBS, Washington, D.C.)
Contract Number COM-74-51058/7W3, 6p.

The varieties of radiation included in safety measurement development are x-rays, nuclides, UV, lasers, EM, and US. NBS is not a regulatory agency, but works closely with these agencies in developing realistic regulations. In this process, the first step is developing a radiation source and observing radiation hazards shortly thereafter. The quantity of the hazard threshold is established as the radiation is used, and both biological and physical scientists as well as radiation technicians are gathered to recommend permissible exposure limits and safe procedures. After these recommendations are reviewed and amended, they are adopted by federal or state legislatures. It is necessary to establish a field measurement system to monitor radiation levels. NBS develops primary standards, and then transfer standards for use in the field. Their EM hazard meter has contributed to the best commercial hazard meters, and is complimentary to them. (No references)

0581 BIOLOGICAL EFFECTS OF MICROWAVES: A BIBLIOGRAPHY WITH ABSTRACTS. (E.) Harrison,
E. A. (Natl. Tech. Inf. Serv., Springfield, Va.).

NTIS No. NTIS/PS-75/384, Mar. 1975.

This bibliography is an update of an earlier publication [see CL 0283, Volume I(3)]. It contains about 100 abstracts of government sponsored research covering biological effects on man and animals resulting from MW exposure. It includes regulations and standards as well as dosages and tolerances. Articles from 1960 through 1974 are included. Each abstract includes document availability and price. (No references)

0582 AN EVALUATION OF POSSIBLE EFFECTS OF 45
Hz, 60 Hz AND 75 Hz ELECTRIC FIELDS ON
NEUROPHYSIOLOGY AND BEHAVIOR OF MONKEYS. (E.)
Gavalas-Medici, R. (Environ. Neurobiol. Lab., Univ.
California Los Angeles) and S. R. Magdaleno. Off.
Naval Res. Tech. Rep., Contract No. N00014-69-A-
0200-4037, 296p., 1975.

Previous studies of ELF electromagnetic fields seemed to indicate that the effect of these fields involved timing behavior in animals. A series of experiments was conducted to provide evidence for a behavioral response in monkeys to ELF, low voltage, electric fields. Five female *Macaca nemestrina* monkeys (3-6 kg) were housed in standard cages and fed a standard laboratory diet. Three of the animals were implanted under anesthesia with a variety of EEG electrodes; the 2 remaining served as controls. The animals were trained in a fixed interval (FI) schedule of reinforcement with differential reinforcement of low rates (drl) and a limited hold (LH). After performance stabilized, they were transferred to a screened testing room and training continued until performance was stable for 6 or more days. The task chosen was not intrinsically challenging and did not require extensive deprivation so that demands of the task would not override possible responsiveness to the presence of the fields. The fields were randomly selected from frequencies of 7, 45, 60, or 75 Hz and voltage levels of 1, 10, 56, or 100 V/m. There was no discernable effect on behavior or EEG patterns at 1 V/m. At 10 V/m there was evidence of a frequency-specific threshold at 7 Hz. Time between responses was significantly shorter and variability of responding was reduced. At 56 V/m the direction of the effect was the same as that at 10 V/m and the magnitude increased markedly for the 7 Hz and 75 Hz fields. At 100 V/m there was evidence of a carry-over effect from one day to the next. In the EEG, there may have been a decrease in percentage power at low frequencies at 56 and 100 V/m, suggesting heightened arousal. There were no differences between implanted vs unimplanted monkeys at any of the levels tested. The detection of weak electric field effects depends on frequency, voltage, duration of exposure, and the exact behavioral assay being used. Weak electric fields will not affect laboratory behavior in experiments demanding the animal's attention. The detection of such an effect requires a precise and detailed record of behavior during prolonged exposure to the field. There is no indication of whether the perturbation noted is good or bad. (24 references)

0583 THE $\alpha\beta\gamma$ OF BIOELECTRIC MEASUREMENTS. (E.) *Electr. Des.* 23(16):68-72, 1975.

There are many problems associated with trying to extract a bioelectric signal from the human body. A low level voltage is being pulled from high level noise while protecting both the patient and the instrumentation. Bioelectric signals are usually in the low millivolt range while the noise level is about 10 volts. To discard unwanted noise ideally, a differential scanner, which takes the difference between two input signals and multiplies by the gain, is used. However, different currents may flow through different parts of the body, unbalancing the impedance. This results from unequal capacitances to ground and unequal electrode impedances. At high input impedances, the susceptibility to capacitive coupling from outside sources is increased. The problem may be avoided by grounding the patient's right leg, but dangerous alternating currents may then flow directly through to the ground. New devices such as pacemakers, catheters, electrodes, intracardiac thermistors and intracardiac microphones all provide direct electric paths to the heart and tiny currents through these may cause ventricular fibrillation. Other more subtle obstacles also exist. (3 references)

0584 IMPROVED SUPPRESSION OF RADIATION FROM AUTOMOBILES USED BY THE GENERAL PUBLIC. (E.) Shepherd, R. A. (Stanford Res. Inst., Menlo Park, Calif.), J. C. Gaddie, and D. L. Nielson. *Fed. Commun. Comm. Rep.* No. FCC/OCE RS75-03, 175p., 1975.

A project was undertaken by the Stanford Research Institute to develop methods to improve the suppression of EMR created by automobile ignition systems over the frequency band from 30 to 500 MHz. This broad band EMR is observable wherever automobiles are used. Having this noise in the environment results in the necessity to increase transmitter power to overcome noise, in turn raising ambient noise level to other spectrum users in a never-ending cycle. The three major sources of incidental radiation are due to HF fast rise time currents flowing in the vehicle's wiring. These fast rise times occur when the gap between the distributor rotor and post breaks down, when the spark plug gap breaks down and when the breaker points close. Each source can be treated individually at little or no extra cost while not increasing air pollution and not affecting engine performance and fuel economy. Spark plug noise is suppressed by a low pass filter built into the spark plug, requiring no new materials and parts. Distributor noise is suppressed by a low-pass filter incorporated into the distributor installed during assembly or later without a need for special tools or training. Breaker point noise can be suppressed by filtering to prevent HF currents from flowing on the breaker point-to-coil wire. However, this noise is so much less than that from the other 2 sources that its suppression may not be warranted. Application of these techniques resulted in suppression improvement of 13-20 dB over the 30-500 MHz range. Measurement of horsepower and exhaust pollutants in-

dicated no effect on these characteristics of the automobile. (24 references)

0585 EFFECT OF THE MAGNETIC FIELD ON THE DIRECTIONAL BEHAVIOR OF GOLDFISH. (E.) Becker, G. (Fed. Inst. Mater. Test., Berlin-Dahlem, West Germany). *Trans. of Naturwissenschaften* 61(5):220-221, 1974.

Goldfish (*Carassius carassius auratus*) frequently orient themselves over a prolonged period of time with their body axis in a N/S, S/N, E/W, or W/E direction. The preferential position along one of the 4 primary orientations of the magnetic field was unmistakable. When not swimming, the fish may be in one of 2 behavioral states: in a random direction oriented by the water motion, or in a more alert condition oriented in the same direction or at a 90° angle to it. If a fish is knocked or vibrated, it spontaneously adopts a N/S, E/W, S/N or W/E orientation in trying to escape. To determine whether the earth's magnetic field actually determines the animal's orientation, fish were individually put in a glass at the center of a Helmholtz coil 1 m in diameter. If the total earth magnetic field of 445-450 mOe is reduced to 220 mOe in the Helmholtz coil, the fish could still orient themselves. When reduced to 110 mOe, they could do so only after several minutes. Eventually orientation in the quiescent state and as a shock reaction ceased, thus demonstrating the ability of the fish to perceive the earth's magnetic field and use it as a direction finder. (10 references)

0586 CONDITIONED CONTROL OF CARDIAC ACTIVITY AND RESPIRATION, AND MORPHOLOGICAL CHANGES IN THE BRAIN OF PIGEONS UNDER THE ACTION OF A CONSTANT MAGNETIC FIELD. (E.) Yakovleva, M. I. (Inst. Exp. Med., USSR Acad. Med. Sci., Leningrad), and M. V. Medvedeva. *JPRS No. 64361*, trans. from *Zh. Vyssh. Nervn. Deyat. im I. P. Pavlova* 22(2):288-293, 1972.

The effect of a CMF on conditioned control of cardiac activity and respiration was studied. Five pigeons were exposed to an 800 Hz, 60 dB tone produced by an acoustic generator as the conditioning stimulus. A 15% ammonia solution was used as the uncontrolled stimulus. Eight combinations of conditioned and unconditioned stimuli were used in the experiment. The size of the response was the increase in cardiac contraction rate within 1 min. Data obtained were compared with the results of morphological research on the brain. The brains were removed for histological examination immediately after the exposures (2 birds) or 3 mon after exposure (2 birds). A distinct rise in reaction rate was observed in 3 pigeons after 8-10 CMF exposures. Examination of the brains of 2 of these pigeons showed edema of the nervous tissue, particularly in the *corpus striatum* of the forebrain and to a lesser degree in the cortical plate and formations of the midbrain. Sharp dilation of the lumens of large and small capillaries and excessive blood volume were noted in the *corpus striatum*. Clearly pronounced hyperplasia and hypertrophy of glial

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elements were noted. Sharp changes in nerve cells near the dilated vessels were observed. In histological examinations done 3 mon after termination of the CMF, only a weak vascular reaction was observed in brain sections and altered neurons and glia were not noted, suggesting that the changes described are reversible. Results do suggest that the CMF affects metabolic processes in the body, especially the CNS, and may lie at the basis of changes in regulation of cardiac activity in response to a CMF on the part of higher regions of the bird CNS. (22 references)

0587 THE EFFECTS OF HIGH POWER PULSED AND LOW LEVEL CW MICROWAVE RADIATION ON AN OPERANT BEHAVIOR IN RATS. (E.) Diachenko, J. A. (U. S. Naval Weapons Lab., Dahlgren, Va.) and W. C. Milroy. *NSWC/DL Tech. Rep.* No. TR-3230, 16 p., 1975.

Two sets of experiments were performed to study the effects of PW and CW MW radiation on an operant behavior in rats. The rats were trained to perform on a DRL schedule and were tested immediately after a one hr exposure to radiation. In the first experiment 12 female Sprague-Dawley rats were maintained at 80% of their ad-lib feeding wt and trained to push a lever not less than 12 nor more than 18 sec after the preceding response. When all had learned they were run for 5 days to establish baseline performance and were assigned to one of 6 pairs depending on the power level of exposure: (1) none (morning control pair); (2) 1 mW/cm²; (3) 5 mW/cm²; (4) 10 mW/cm²; (5) 15 mW/cm²; and (6) none (afternoon control pair). The frequency of exposure was 2450 MHz. They received 5 days of EM exposure, 1 hr/day, 2 days sham exposure, then one more day of exposure. Performance testing immediately followed each exposure and lasted 1 hr. No significant changes were noted except on the 5th day of exposure of the pair at 15 mW/cm². These animals showed obvious signs of heat stress and remained completely inactive up to 7 min after removal from the exposure chamber. In the 2nd experiment, 8 male Sprague-Dawley rats maintained at 80% of their ad-lib feeding wt were trained as in experiment 1 and 4 of these were exposed to PW radiation with a field strength of 125 kV/m and 4-10 pps. The others were exposed to 5 or 10 mW/cm² CW radiation. None of the rats showed any appreciable change in performance. The results suggest that acute exposure to CW radiation at 10 mW/cm² or less for 1 hr or high power PW radiation has no deleterious effect on operant behavior. Exposure at 15 mW/cm² produces obvious signs of heat stress but the subject recovers quickly. This also suggests that the margin of safety is slim for a radiation standard of 10 mW/cm². (11 references)

0588 CUTANEOUS MICROWAVE INJURY: REPORT OF TWO CASES. (E.) *Year Book Dermatol.* :125, 1974.

A 50-yr-old woman who operated a MW oven routinely for 4 yr noticed a lesion on the left index finger

near the nail base when a malfunction of the oven resulting in burning of food occurred. The disorder spread to 3 fingers of the right hand. Transverse ridging and deformity of the nails was observed. After application of a topical steroid cream there was gradual improvement over 6 wk. A similar nail problem was observed in a 56-yr-old woman employed in the same place for 1.5 yr. Up to 10,000 MHz, MW energy is absorbed by the more superficial tissues. At 2450 MHz, the radiation level of MW ovens, the damage from heat may occur without being perceived by the operator. (No references)

0589 NEURONAL EFFECTS OF LOW LEVEL MICROWAVES. (E.) Seaman, R. L. (Duke Univ., Durham, N. C.) *Diss. Abstr. Int. B* 35(12):5867-B, 1975.

The neurons in the abdominal ganglion of *Aplysia californica* were used to study individual neuron responses to irradiation. The neurons were placed in a strip-line which allowed both direct observation of, and electrical recording from, the sample during irradiation. The electrical activity of white cells and bursting neurons, which exhibit endogenous firing patterns, were studied. Most of the changes noted resembled responses to temperature rises. However, a small number of observed responses could not be explained in terms of temperature rise and mechanisms for induced current during irradiation are proposed. Half of the neurons were affected by absorbed powers of 15 mW/cm² or less. These facts suggest that a reconsideration of thermal criteria presently used to predict MW effects may be necessary. (No references)

0590 THE EFFECT OF UTRAHIGH FREQUENCY ELECTROMAGNETIC FIELD ON IMMUNOBIOLOGICAL REACTIVITY. (Rus.) Vinogradov, G. I. (V. A. Marzeliy Res. Inst. Gen. Munic. Hyg., Kiev, USSR). *Vrach. Delo* (6): 122-125, 1975.

Studies were conducted of the effect of UHF on the total number of leukocytes, white blood cells, phagocytosis and complement titer in 75 guinea pigs which were divided into groups exposed daily at power densities 50, 10, 5 and 1 μ W/cm² for four weeks (7 hr total exposure). The findings showed that exposure at 1 and 5 μ W/cm² resulted in the increase of leukocytes immediately after the experiment (6.86 ± 0.14 and 7.72 ± 0.19 , resp.) while at 10 μ W/cm² the increase was observed only eight wk after the experiment. Neutrophils and eosinophils increased significantly (51.8 ± 3.9 and 2.7 ± 0.009) two weeks after the exposure at 5 μ W/cm². The rise of the phagocytic activity, both ingestive and digestive, was most pronounced at 5 and 1 μ W/cm² lasting up to 8 wk after the exposure. Complement titer increased markedly (0.08 ± 0.004) 4 wk after the exposure at 1 μ W/cm². It is concluded that UHF irradiation stimulates white blood cell circulation immediately after the exposure and 2-4 wk later. It was observed that lower power densities tended to enhance cellular and humoral immunity. (No references)

0591 ABSENCE OF HEART-RATE EFFECTS IN ISOLATED FROG HEART WITH PULSE MODULATED LOW-LEVEL MICROWAVE ENERGY. (E.) Clapman, R. (Dep. Electr. Eng., Univ. Illinois, Urbana) and C. Cain. 1974 IEEE Electromagn. Compat. Symp. Rec., 107-109, 1974.

Isolated hearts from the frog *Rana pipiens* were irradiated with pulsed MW energy for 1 min (peak power density 5.5 W/cm^2 , 2 μsec pulses). The radiation occurred either at the peak of the P wave, 100 msec after the P wave, 200 msec after or during the minute but not synchronous with the P wave. The heart was placed on a lucite mount dorsal side up with the longitudinal axis parallel to the E vector. The heart was moistened with 5 ml of frog Ringer's solution and heart rate was stabilized. In all experiments there was one minute of stabilized heart beat with no irradiation, one min of irradiation and one min afterwards of no irradiation. Temperature changes were found to be insignificant. The small differences between experimental and control groups were not statistically significant. No sign of positive feedback was seen. (10 references)

0592 EFFECT OF 2450-MHz RADIATION ON THE RABBIT EYE. (E.) Guy, A. W. (Dep. Rehabil. Med., Sch. Med., Univ. Washington, Seattle), J. C. Lin, P. O. Kramar, and A. F. Emery. IEEE Trans. Microwave Theory Tech. MTT-23(6):492-498, 1975.

The MW field and power patterns inside and outside the head and eye when exposed to near-zone 2450 MHz radiation were determined using New Zealand white rabbits. Time and power thresholds for cataractogenesis were clarified and computer models to study intraocular temperature during radiation were applied. In all experiments the rabbits were placed in an acrylic box with head and hind legs outside and were exposed to the near-zone of a 2450 MHz corner reflector with horizontal polarization. The distance between the crossing point of the dipole feed and the corneal surface of the eye was 5 cm. For dosimetry measurements, a fast-reacting thermocouple was passed into a probe in the eye and intraocular temperature measurements were taken at 2 mm increments prior to and just after a 20 sec exposure to 540 mW/cm^2 high intensity radiation. The absorption reached peak values within the vitreous body 1.5 cm behind the cornea and had a mean of 0.92 W/kg for each mW/cm^2 incident power. The rabbits showed an increase of about 0.97°C in rectal temperature and 30% pulse rate increase. In the 2nd experiment MW radiation at a predetermined level was performed at 5 min intervals with the temperature recorded by a thermocouple probe in the eye. The peak temperature for 100 mW/cm^2 for 60 min, 200 mW/cm^2 for 35-40 min, and 300 mW/cm^2 for 30-35 min was determined. The absorbed power was 90, 180, and 270 W/kg , resp. Each power level reached its own specific temperature plateau after 15-20 min due to an increase in body core temperature. The orbital temperature never rose as high as the vitreous due to greater blood flow and heat regulatory capacity. Rabbits exposed to 200 and 300 mW/cm^2 all developed lens opacities. Eighty-one rabbits were used to determine the cataractogenic threshold for near-zone 2450 MHz radiation.

Under sedation the right eye was irradiated in an anechoic chamber while the left eye served as control. Low and high power densities were used at various exposure durations. Slit lamp examinations were performed immediately after irradiation and periodically thereafter. At lower exposure levels mild, reversible changes were noted. At higher levels, more advanced and permanent cataract changes were seen, generally confined to the posterior cortical area. The control eye remained normal. The minimum cataractogenic power density was 150 mW/cm^2 for 100 min, or 138 W/kg maximum absorbed power. Computer modeling of the temperature distribution of an intact eye gave results in complete agreement with the measured retrolental temperature rise. Comparison of measured and computer estimates revealed a possible threshold cataractogenic temperature of about 41°C in the eye, suggesting a possible localized heating mechanism responsible for MW cataractogenic effects. (13 references)

0593 BIOMEDICAL APPLICATIONS OF EM RADIATION. (E.) Ecker, H. A. (Georgia Inst. Technol., Atlanta). Microwave J. 18(7):47-50, 1975.

Three potential new applications of EMR for medicine and biology are discussed in this paper, including heating of cancer tumors, thawing of frozen organs, and thawing of granulocytes. Selective heating of tumors in deeply cooled animals enhances the effectiveness of chemotherapy treatment. The animal is cooled to $40-50^\circ\text{F}$ and EMR is used to raise and maintain the tumor temperature at 98°F through selective, uniform heating. The cooled healthy tissue utilize little of the destructive drug while the warm tumor, with a high metabolic rate, is affected to a much greater degree. A modified technique combines the HF radiation with doping the tumor with high loss particles. This concentrates the heating in the doped area. Thawing of frozen organs offers hope for the development of long-term organ banks. The heating must be uniform and rapid and may be accomplished by using multiple frequencies and configurations of EMR, as well as inserting small spheres within the organ to enhance thawing from the center toward the surface. Conventional thawing of blood kills granulocytes which are given to patients on anticancer drugs to enable the body to fight common infections. With a properly shaped horn and multiple frequencies, frozen bags of granulocytes and lymphocytes were thawed in 70 sec from -196°C to $+1^\circ\text{C}$. In vitro viability tests were positive in each case. (7 references)

0594 ENERGY METABOLISM OF THE HYPOTHALAMO-HYPOTHYSEAL PART OF RAT BRAIN IN THE ANTITUMORAL EFFECT OF A MAGNETIC FIELD. (E.) Ukolova, M. A. (Sci. Res. Oncol. Inst., Rostov-on-Don, USSR), Y. B. Kvakina, and G. Y. Chernyavskaya. JPRS No. 64370, trans. from Vopr. Onkol. 15(12):60-64, 1969.

The antitumoral effect of a magnetic field stems from both direct cytostatic action on tumor cells and from

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regulatory mechanisms of the hypothalamic regions of the brain. Indices of energy metabolism in the hypothalamo-hypophyseal region of the brain of Wistar rats and common male rats were studied. These rats had 1st generation sarcomas induced by 3,4-benzpyrine in the presence of magnetic fields. The magnetic field was created with permanent bar magnets with an induction of 500-700 G. Tissue respiration and glycolysis were determined manometrically. The determinations were made with intact rats, rats without tumors after 5-6 magnetic exposures, rats having tumors resorbed after magnetic exposure, rats with tumors not subject to magnetic exposure, and rats in which tumors continued to grow despite the magnetic field. In response to the magnetic field the intensity of tissue respiration increased in the hypothalamo-thalamic region of the brain of intact animals and animals with resorbing tissues. Free oxidation increased in intact animals and the level of all oxidative processes rose in rats with resorbing tumors. Glycolysis increased sharply in intact animals in response to a magnetic field, and remained high in rats after resorption of tumors. In rats with resorbed tumors, change in energy metabolism occurred in the hypothalamo-thalamic region of the brain characterized by intensification of oxidative processes. These changes were not observed when the magnetic exposure was ineffective. (23 references)

0595 EFFECT OF A HIGH-INTENSITY MAGNETIC FIELD
ON ENZYMATIC HYDROLYSIS OF NUCLEIC ACIDS.
(E.) Komolova, G. S. (Inst. Biochem. im. A. N. Bakh, USSR Acad. Sci., Moscow), G. D. Erigin, T. B. Vasil'yeva, and I. A. Egorov. JPRS No. 64370, trans. from Dokl. Akad. Nauk SSSR 204(4):995-997, 1975.

DNA is known to orient itself with the long axis perpendicular to the lines of a magnetic field. Changes in the kinetics of enzymatic processes associated with the rod-shaped macromolecules of DNA and RNA can be expected in a magnetic field. Studies were made of the DNA-DNAase and RNA-RNAase enzyme systems in a constant magnetic field. Enzymatic hydrolysis was conducted at 25°C for 1.5 hr while the mixture was circulated through a closed system of tubes in the presence or absence of a magnetic field. The enzyme-substrate ratio was 1:5000 for RNAase and 1:50 for DNAase. The field intensities used were 0.8×10^3 , 1.2×10^3 , and 3.2×10^3 Oe. In the range used, no differences were observed between experimental and control RNAase activities. For the DNA-DNAase system maximum action of the magnetic field was detected at 3.2×10^3 Oe with a decrease in the effect at lower intensities. The effect disappears at 0.8×10^3 Oe. Thus, the magnetic field effect is expressed as a heightening of DNAase activity by 30% at the maximum. There is a definite threshold below which the effect is not manifested - between 1.2×10^3 and 0.8×10^3 Oe for DNA. Much higher intensities are required for manifestation of the effect on RNAase activity. The data indicates that a magnetic field can have a modifying effect on a whole series of biochemical processes associated with enzymatic breakdown of DNA under normal conditions and in the pathology of cells *in vivo*. (10 references)

0596 EFFECT OF A PULSED MAGNETIC FIELD ON CHICK EMBRYOS IN THE 48TH HOUR OF INCUBATION, AND ON HATCHING RATE. (E.) Khananayev, L. I. (no affil.) and D. T. Borodaykevich. JPRS No. 64370, trans. from Biol. Nauki (5):54-58, 1973.

The effect of a PMF on development of chick embryos and on the hatching rate was studied. Eggs from white Leghorn chickens were distributed into 3 groups as follows: (1) 56 eggs subject to a PMF for 30 min; (2) 53 eggs subject to a 60 min exposure; and (3) 53 eggs served as control. Prior to incubation the eggs were subjected to a single 14,000 Oe PMF exposure (pulse length 220 μ sec, interpulse interval 20 sec). Some embryos were used in histological preparations after 48 hr of incubation and some were used on the 6th day for measurements of embryo development stages. All chicks hatched on the 21st day. Hatching was simultaneous in controls and group 2, but was 8-10 hr earlier in group 1. The largest number of abnormal embryos were in group 2 while the smallest were in the first group. The large and small diameters of the area vasculosa were greater in group 1 after 48 hr of incubation than in the other 2 groups. Length of embryos were 4.2, 3.8, and 3.7 mm in groups 1, 2, and 3, resp. Thus, irradiation in a 14,000 Oe pulsed magnetic field for 30 min had a favorable effect on development and hatching rate of the chick while a 1 hr exposure had a moderately inhibitory effect. (26 references)

0597 ELECTROMAGNETIC POWER ABSORPTION IN ANISOTROPIC TISSUE MEDIA. (E.) Johnson, C. C. (Dep. Bioeng., Univ. Utah, Salt Lake City), C. H. Durney, and H. Massoudi. IEEE Trans. Microwave Theory Tech. MTT-23(6):529-532, 1975.

Below 100 Hz, a strong conductance anisotropy is known to exist in muscle tissue. In this work an idealized anisotropic tissue medium, consisting of infinitely long parallel muscle fibers, is assumed. These fibers generate relaxation effects only when there are E-field components perpendicular to the fibers. A theory for field effects in anisotropic tissue is developed based on this model. In analyses carried out for multiple tissue layers, the one-layer model predicts a 10:1 difference in power absorption with polarization at 0.01 MHz and below, the 2-layer model predicts a 12% difference, and the 5-layer model predicts a 5:1 difference. Thus, it is predicted theoretically that marked differences in tissue-absorbed power density can occur due to tissue anisotropy at frequencies below 10 MHz. A finite layered model such as an anisotropic sphere is needed to extend these results. (4 references)

0598 MODIFICATION OF THE CYTOGENETIC EFFECT OF IONIZING RADIATION UNDER THE INFLUENCE OF PERMANENT MAGNETIC FIELDS. (E.) Galaktionova, G. V. (no affil.) and A. D. Strzhizhovskiy. JPRS No. 63856, trans. from Kosm. Biol. Aviakosmicheskaya Med. 8(6):25-28, 1974.

A study was performed of the modifying effect of a

PMF on post-radiation changes in the mitotic index and frequency of aberrant mitoses in the epithelial cells of the cornea in mice. Mice of the CBA and C₅₇B1 strains were subjected to ionizing radiation of 400 rad separately and in combination with a PMF of 1000-4500 Oe. After exposure the animals were decapitated and total preparations of the cornea were made. In the 2 lower layers of reproductive cells the number of mitoses/5000 cells and frequency of aberrant mitoses were counted. Four series of experiments were carried out. In the first 2, the cytogenic effects of ionizing radiation of Co⁶⁰ separately and in combination with 3 hr exposure to a 4500 Oe PMF were studied. No statistically significant differences in values of the mitotic index were noted. In the 3rd series, after exposure to ionizing radiation, the animals were subsequently exposed to a PMF of 1000 Oe for 5 days. No significant differences in post-radiation changes were observed. In the 4th, the animals were exposed to a PMF of 1000 Oe for 15 days before exposure to ionizing radiation. A modifying effect was noted due to preliminary changes in animal metabolism under the influence of PMF, but there was no direct influence on the formation or development of radiation damage itself in any of the experiments. (10 references)

0599 BIOLOGICAL EFFECT OF PERMANENT MAGNETIC FIELDS. (E.) Nakhil'nitskaya, Z. N. (no affil.). JPRS No. 63856, trans. from Kosm. Biol. Aviakosmicheskaya Med. 8(6):3-15, 1974.

This article is a review of the literature on the biological effects of PMFs of high and low strength which may be of interest for predicting the after effects of man's and animal's exposure. There are few studies, and many of them are contradictory. Beischer has concluded that no cumulative effects are seen after a year of exposure to a field with a strength up to 20,000 Oe over the entire body. Others have shown that 10-150 Oe fields can cause local vasoautonomic disturbances and general functional disorders, primarily in the cardiovascular, nervous, and blood systems. Despite this sensitivity, animals are capable of tolerating exposure to uniform MFs with a very high strength without any influence on their lifetime. Most effects discovered were transient and regressed immediately after exposure ceased. The question of adaptation to this exposure is still open. The effects of MFs less strong than the geomagnetic field have not been widely studied and results are contradictory. Joint efforts by physicians, biologists, physicists and chemists are necessary to study the complex problems in this field. (194 references)

0600 THE COMBINED EFFECT OF ALS, ALG AND ELECTROMAGNETIC RADIOWAVES ON THE ABSOLUTE AND RELATIVE BLOOD COUNT IN EXPERIMENTAL SKIN TRANSPLANTATION. (Ukr.) Gorodetskaya, S. F. (Dep. Exp. Ther., Acad. Sci., Kiev, USSR). Fiziol. Zh. Acad. Nauk RSR 20(4):502-507, 1974.

Intensification of the immunodepressive effect of UHF radiation in conjunction with the application of

ALG and ALS (biological immunodepressants) during skin transplants in rabbits was investigated. The effect on absolute and relative numbers of lymphocytes in peripheral blood with transplantation was also studied. Radiowaves 1 cm in length and 100 mW/cm² intensity were used. Experimental data showed that there was a correlation between the decrease of the absolute and relative number of lymphocytes in peripheral blood, and the increase in the lifetime of skin transplants. Also, the combined effect of ALG and ALS with irradiation prolonged the average lifetime of the skin transplants approximately 200% over the average lifetime of such transplants in control species. Irradiation alone (without use of ALG and ALS) prolonged the lifetime of transplants over control species by approximately 100%. (10 references)

0601 NEUROLOGICAL CHANGES IN SUBJECTS EXPOSED TO HIGH FREQUENCY ELECTROMAGNETIC FIELDS. (Pol.) Langauer-Lewowicka, H. (Clin. Occup. Dis., Inst. Med. Occup. Coal Mine Ind., Sosnowiec, Poland). Neurol. Neurochir. Pol. 9(2):203-210, 1975.

The effect of prolonged occupational exposure to HF radiation was studied in 33 women, aged 21-53, exposed daily for 1.5-17 yr to a 1-1000 V/m field. Observations were rendered more difficult by the non-specific nature of the symptoms appearing in the affected subjects: headaches, pain in the region of the heart, irritability, insomnia, dizziness, and general weakness. Interruption of occupational duties for a period of 6-12 mon eliminated part of the symptoms (headache and insomnia) in some of the subjects and none in others. EEG recordings of the investigated subjects led authors to the conclusion that high frequency EMR may cause permanent structural damage in the nervous system. (19 references)

0602 DIELECTRIC MEASUREMENTS FOR HYDRATION OF GLOBULAR PROTEINS. (Ukr.) Kashpur, V. A. (no affil.), V. Y. Maleev, and T. V. Shchegoleva. Dopov. Akad. Nauk Ukr. RSR, Ser. B:150-152, 1975.

The degree of hydration of a group of globular proteins was studied by dielectric measurements, applying 0.76 cm UHF radiation. Proteins examined included: protein of blood serum of bull, egg albumin, chymotrypsinogen, ribonuclease, pepsin, papain, cytochrome c, hemoglobin and myoglobin. When compared with other methods for determining the degree of hydration (calorimetric, sorption and NMR) the dielectric method showed proper correlation with these, as to the relative magnitudes of hydration among individual proteins investigated. With respect to absolute magnitudes of hydration, it showed consistently lower values. On the other hand, hydration values obtained by the dielectric method agreed very well, with a few exceptions, with the values theoretically predicted by models of Bull and Kuntz, emphasizing the importance of the first hydration layer. Only experimental values for cytochrome c and hemoglobin obtained by the dielectric method showed hydration values considerably higher than those predicted by models of Bull and Kuntz. (11 references)

0603 LONG-WAVELENGTH ELECTROMAGNETIC POWER ABSORPTION IN PROLATE SPHEROIDAL MODELS OF MAN AND ANIMALS. (E.) Johnson, C. C. (Dep. Bioeng., Univ. Utah, Salt Lake City), C. H. Durney, and H. Massoudi. *IEEE Trans. Microwave Theory Tech.* MTT-23(9):739-747, 1975.

The time-averaged volumetric tissue-absorbed power density, defined as the time rate at which energy is absorbed by the tissue, was determined. The low k_a perturbation theory was applied to prolate spheroid models of man and experimental animals to obtain internal EM absorbed power distributions and total absorbed power for different orientations and frequencies. Comparisons were made with experimental measurements. A strong orientation effect, which is a critical factor in determining absorbed power, was found. Theoretical data was obtained for absorbed power distribution and total absorbed power for 3 orthogonal orientations of the prolate spheroid with respect to the plane-wave field vectors. Once biological effects due to tissue-absorbed power density are established, the plots may be used to extrapolate back to find what incident plane wave power densities generate the same tissue absorbed density in the man model. This will serve as a guide to establishing EM radiation safety standards. (18 references)

0604 MEASUREMENT OF PERMITTIVITY OF SOLUTION OF SMALL BIOLOGICAL MOLECULES AT RADIOWAVE AND MICROWAVE FREQUENCIES. (E.) Lawinski, C. P. (Phys. Dep., Queen Elizabeth Col., London, U.K.), J. C. W. Shepherd and E. H. Grant. *J. Microwave Power* 10(2): 147-162, 1975.

A coaxial line cell was designed which extended the lower frequency limit to give accurate values of the complex permittivity ϵ for aqueous solutions in the 50 to 200 MHz range. Measurements of the complex permittivity of 0.25 M triglycine were made at 24 different frequencies between 55 MHz and 4 GHz and 5 temperatures (5, 12.5, 20, 30, and 40 C) using the coaxial line cell. This cell operates on the principle of measuring the waveform in the sample contained in the cell by means of a probe projecting through a sliding inner conductor moving within the sample. The main purpose of the work was to determine the dispersion of the triglycine molecule accurately. A continuous increase in ϵ between 40-800 MHz, followed by a small peak before rising again at frequencies above 2 GHz was seen. This has relevance to the biological effects of MWs and to MW hazards as these rises are paralleled by considerable increases in conductivity and attenuation coefficients, which are parameters directly determining energy absorption from MWs. (28 references)

0605 THE EFFECTS OF COMBINED SHF AND GAMMA IRADIATION ON HEMOPOIESIS. (E.) Tikhonchuk, V. S. (no affil.). JPRS No. 62942, trans. from *Kosm. Issled.* 12(3):478-482, 1974.

The effect of the biological interaction of EM waves and ionizing radiation was studied with respect to

the hemopoietic system. Female C₅₇B₁ mice were exposed to a 100 mW/cm² power flux density SHF for 4 min/day for 31 days, followed by a 400 r dose of γ radiation (Co-60). The weights of the spleen and thymus were measured and the number of cellular elements in the peripheral blood were counted. Following exposure to SHF radiation both the spleen and thymus decreased in weight and rose to initial values by the 31st day of exposure. Following termination of SHF exposure, weights again fell to 76% and did not recover. Four hr after the 1st exposure to SHF radiation leukocytosis was evident, primarily due to the increase in the number of lymphocytes. After 20 days leukopenia was found, and an unsteady situation remained for some time after termination of exposure. After irradiation a decrease in weights of the spleen and thymus was evident to a combination of SHF and γ rays and to γ radiation alone. Weight recovery was more rapid in the group exposed to γ radiation alone. Four hr after γ radiation the number of leukocytes was 71% of control, while that of animals who were pretreated with SHF was 46% of controls. Thus, SHF has an inhibitory effect on the function of the hemopoietic system and significantly alters its responsiveness to such extreme factors as ionizing radiation. (9 references)

0606 THE EFFECTS OF SUPERHIGH FREQUENCY ELECTROMAGNETIC FIELDS (SHF-EMF) ON THE BODY. (E.) Molchanova, N. S. (Acad. Med. Sci. USSR) and Y. V. Gembitskiy. JPRS No. 62942, trans. from *Voyenna-Polevaya Terapiya* (Leningrad, 1973), pp. 198-206.

A review of the effects of SHF electromagnetic fields on the body is presented. The biophysical mechanism of SHF absorption is not completely understood but may rest on the appearance of fluctuations in ions and water dipoles. High intensity irradiation is accompanied by thermal effects, particularly in poorly vascularized organs and tissues. The nervous system is also highly susceptible to MW effects. Studies demonstrating a nonthermal, specific effect of low doses of radiation are available. These include headache, weakness, vertigo, nausea and various symptoms of CNS dysfunction with vegetative vascular and visceral dysfunctions. Detection of malfunctions requires both careful clinical evaluation and a study of occupational history and nature of the hygienic working conditions. The most successful treatment is termination of contact with SHF EMFs, psychotherapy to dissipate unbased fears, and CNS stimulants. Preventive measures include control over working conditions and protective clothing and glasses. (No references)

0607 AN EVALUATION OF ELECTROANESTHESIA AND ELECTROSLEEP. (E.) Comm. Electr. Stimul. Brain, Natl. Res. Counc., FDA Contract No. 70-22, 54p., 1974.

It has been pointed out that some permanent physiologic damage may result from the passage of electric

current through the human brain. The efficacy of devices for delivering such current has not been thoroughly evaluated. 'Application of electric current to the head' (AECH) is used to describe electro-sleep, electronarcosis, electroanesthesia, and electrical cerebral stimulation. Electric current for anesthesia is administered only after pharmacologic agents and intubation are given, controlled ventilation is established, and some measure of anesthesia by pharmacologic means is induced. The physiologic effects of AECH depend on current amplitude, electrode location and wave form or frequency. The ultimate goal of AECH for anesthesia is to produce quickly and maintain effectively a state of surgical anesthesia without cardiovascular and respiratory depressant effects of pharmacologic drugs. The patient returns to consciousness within seconds of cessation of the current, and postanesthesia nausea and discomfort are rare. However, muscular activity, tachycardia, hypertension with excessive bleeding and increased salivation have been described, as well as some cases of minor skin burns at the electrode site. An understanding of the specific anesthetic mechanism of AECH has not been established. Recommendations for further study include (1) considering AECH as a potentially useful adjunct in the maintenance of anesthesia, (2) limiting AECH to investigational use until documentation of its effects, advantages, and standardization are attained and (3) studying the effect of AECH on cerebral tissue. (94 references)

0608 SEARCH FOR CORRELATION BETWEEN GEOMAGNETIC DISTURBANCES AND MORTALITY. (E.) Lipa, B. J. (Inst. Plasma Res., Stanford Univ., Calif.), C. W. Barnes, P. A. Sturrock, M. Feinleib, and E. Rogot. *SUPLR Rep.* No. 623, NSF Grant GA-42401 and NASA Grant NGL 05-020-272, 11p., 1975.

Speculative research on solar terrestrial relations has been concerned with possible associations between solar activity or geomagnetic disturbances and human disorders. Various authors have claimed a real association between these disturbances and myocardial infarction, psychological behavior, CNS activities and various diseases. In this research, statistical analyses were performed on mortality data obtained from the National Center for Health Statistics and geomagnetic data from the World Data Center. Daily deaths due to coronary heart disease and stroke vs magnetic activity, death rate vs magnetic index, mortality rates vs geomagnetic indices in individual cities, and death rate vs the W-index for micropulsations were measured. No statistical evidence for a real correlation was found to exist in any of this work. (9 references)

0609 MORTALITY IN RATS EXPOSED TO CW MICROWAVE RADIATION AT 0.95, 2.45, 4.54, AND 7.44 GHz. (E.) Polson, P. (Stanford Res. Inst., Menlo Park, Calif.), D. C. L. Jones, A. Karp, and J. S. Krebs. *Tech. Rep.* No. DAAK02-73-C-0453, 90p., 1974.

Little quantitative data has been available on MW lethality. In this study 1400 male Sprague-Dawley

rats were exposed to CW microwave radiation of 0.95, 2.45, 4.54, or 7.44 GHz, with power density levels of 0.2 to 12 W/cm². The rats were habituated to handling for 3 wk, then irradiated in an exposure box designed to minimize movement by the animal. Each animal was observed for mortality at removal from the box and during the next 3 days. After 3 days the surviving animals were sacrificed. Deep rectal temperatures were taken immediately after exposure at the 2 lower frequencies. Twenty-four animals were subjected to a gross necropsy, and histological examination of the brain, kidney, liver, spleen and lung. No histological abnormalities associated with MW irradiation were observed. At 0.95 GHz, with few exceptions, animals which died usually showed a foamy mucus nasal discharge and were either limp or in convulsions. At 2.45 GHz in addition to symptoms noted at 0.95 GHz, frank hemorrhage of the lung and froth in the trachea was apparent. At 4.54 GHz, 193 of the 208 rats died by the end of the first post irradiation day. Marked salivation was present, along with frank burning of ears, eyes and skin in the muzzle area and swelling of the muzzle. Convulsion and respiratory insufficiency were again common at 7.44 GHz. Mortality was associated with asphyxia primarily due to blockage of the nasal passages by hemorrhage or 3rd degree burns. No apparent relationship was found between either body wt or rectal temperature and mortality. Regardless of frequency, the primary site of damage appeared to be the blood vessels with edema and hemorrhage representing the result of changes in permeability of vessel walls. The blood vessels appear to be the most sensitive tissue as sites for deposition of MW energy. The area of damage appeared to move from the lungs to the nose as frequency increased from 0.95 to 7.44 GHz. LD₅₀s and power densities form a rectangular hyperbola for each frequency. Lethality of radiation decreased with frequency in the order 0.95>2.45>7.44>4.54 GHz. The difference in effectiveness between 4.54 and 7.44 GHz implies a real difference in biological response. At each frequency the energy density required to achieve LD₅₀ is a linear function of the exposure duration. No effects which would be attributed to circadian rhythms were observed. (9 references)

0610 A PRIMATE RESTRAINT CHAIR FOR USE IN MICROWAVE RADIATION STUDIES. (E.) Reno, V. R. (Naval. Aerosp. Med. Res. Lab., Pensacola, Fla.), J. O. deLorge, G. D. Prettyman, C. S. Ezell, and T. A. Griner. *Tech. Rep.* No. NAMRL-1211, 10p., 1974.

A common method of indirect measurement of energy absorbed by an animal from an incident MW field is by introduction of the animal into a previously measured field. The field incident on the animal is assumed to be that measured in its absence. This assumption is valid only if the animal is the only object in the field or if the restraint device is essentially nonreflective and nonabsorptive. By careful consideration of theoretical and practical factors, it is possible to design animal restraint chairs which eliminate many of the problems caused by MW reflection. A restraint chair which is nonreflective and causes minimal perturbation of the incident field has been developed for subhuman primates in MW research. The

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chair is made of Styrofoam HD-300, a foam plastic of low MW reflectivity. The material is a closed cell, polystyrene foam with reasonable mechanical strength. It is resistant to moisture penetration and therefore easy to clean. Dovetailed grooves are used at the joints since conventional fasteners are highly reflective. The animal is introduced into the chair from the back and the neck yoke is inserted and locked. The seat is inserted so that the animal assumes a sitting posture. The chair can be oriented in any direction. Field scans at the same location with and without the chair give excellent agreement, indicating minimal reflection. This device reduces some of the uncertainties in the complex problems of MW biodosimetry. (3 references)

0611 PERMEABILITY OF THE MUCOUS MEMBRANE OF THE FRONTAL SINUS UNDER THE INFLUENCE OF MICROWAVES. (E.) Faitel 'berg-Blank, V. R. (Dep. Pathol. Physiol. Biophys., Odessa Agric. Inst., USSR) and M. P. Khareyn. *JPRS No. 62520, trans. from Fiziol. Zh. (Kiev)* 20(1):100-107, 1974.

High frequency EMFs are widely used for the treatment of frontal and maxillary sinuses. The effects of various doses of MWs on the permeability of the mucous membrane of the frontal sinus was studied. Sixty cats were used as controls. Disubstituted phosphoric acid salt ($Na_2HP^{32}O_4$) was injected into the left frontal sinus. At various times up to 120 min blood samples were obtained and activities measured. After 120 min the animals were electrocuted and samples were obtained from different regions of the brain and parenchymatous organs. Radioactive phosphorus activity was determined in these. Sample cats were irradiated with 30, 50, and 72 W microwaves applied for 10 or 20 min to the frontal sinus. The permeability of P^{32} and its distribution among the organs under investigation were measured. Under normal conditions, radio-phosphorus is absorbed rapidly and deposited in the parenchymatous organs. The intensity and rate of absorption is markedly enhanced by exposure to 30 W MWs for 10 min with maximum accumulation in the blood occurring within 45 min and amounting to 16.6% of incorporation compared with 7.72% at that time in controls. There was a significant decrease in radioactive phosphorus in the brain tissue and increase in parenchymatous organ tissue. Exposure to 50 W MWs for 10 min also resulted in enhanced absorption, but little difference is seen after exposure to 75 W MWs. Thus, MWs alter permeability of the mucous membrane to an extent dependent on intensity and duration. Tissue of the brain and parenchymatous organs change permeability in relation to MW dose, indicating an alteration in metabolism in these organs. This data may be used by otolaryngologists in selecting MW doses in therapy of frontal sinus diseases. (22 references)

0612 A PERSPECTIVE ON ENVIRONMENTAL HEALTH IN THE USSR. (E.) Glass, R. I. (Dep. Med., Mt. Sinai Hosp., New York, N.Y.). *Arch. Environ. Health* 30(8):391-395, 1975.

Soviet methods for setting and enforcing environmental

standards have been observed. The Soviet government operates as both the prime source of pollution and the sole regulator of pollution levels. The Ministry of Health of the USSR is responsible for planning and promoting research on new pollutants, translating the results into national standards, and ensuring the enforcement of these standards. Environmental standards are based on research in health effects alone, without regard to considerations of available technology, economic feasibility or ability to measure these concentrations in practice. Duplication of scientific effort is not allowed, preventing verification of controversial results. The MW standard is a thousandfold lower than the American equivalent because it is based on nonthermal effects. As interest in effects of physical factors in the environment has increased in the West, Soviet research serves as a basis for further study. (14 references)

0613 A PSYCHOBIOLOGICAL STUDY OF RHESUS MONKEYS EXPOSED TO EXTREMELY LOW FREQUENCY-LOW INTENSITY MAGNETIC FIELDS. (E.) deLorge, J. (Naval Aerosp. Med. Res. Lab., Pensacola, Fla.). *Tech. Rep. No. NAMRL-1203, 25p.*, 1974.

The effects of low intensity ELF magnetic fields were studied using four rhesus monkeys (*Macaca mulatta*). The experiments were designed to explore possible changes in time dependent behavior and blood chemistry. Blood samples were taken before, during and after the experiments. Various tests were run, including an interresponse time (IRT) schedule and a fixed ratio (FR) schedule with animals held at different percentage body weights and exposed to 15-45 Hz magnetic fields. Triglycerides were previously reported to increase following ELF exposure in man, but no significant changes were noted in this study. ELF fields have been shown to be useful to drive a drug-induced failing heart in the rat, but no significant differences were seen in CPK, cholesterol, LDH, potassium and SGOT. Calcium, RBC, hemoglobin and hematocrit were measured because of a purported relationship between respiration, oxygen uptake and ELF electromagnetic fields, but no influence of the magnetic fields was observed. No effects were seen on WBC, monocytes, eosinophiles, polycytes, etc., and no effect was noted on kidney or liver functions. ELF magnetic fields showed no obvious behavioral influence on either FR or IRT schedules, and general activity was not affected. The tests showed no initiating effects of the fields and no evidence that the animals adapted to the fields. While the behavior of the animals, as measured, was not affected to any practical extent, the possibility of an individual being influenced is not precluded. (14 references.)

0614 THE EFFECTS OF ELECTROSLEEP ON INSOMNIA REVISITED. (E.) Cartwright, R. D. (Dep. Psychol., Univ. Ill., Chicago) and M. F. Weiss. *J. Nerv. Ment. Dis.* 161(2):134-137, 1975.

Ten subjects suffering from objectively and subjectively defined insomnia participated in a double

blind study to determine the effects of electrosleep on this problem. Half of the group were given 24 treatment sessions, and half received 24 sham treatments. A 2 week no treatment interval followed, and a 2 year follow-up was done. All sleep symptoms improved for both groups over the time interval involved, however significant long lasting improvement was only seen in the actual treatment group. In this group 4 of the 5 subjects were able to fall asleep with little difficulty and to awake feeling moderately to very well rested during the 2 yr no-treatment period. The trend indicates that the sleep habits were improved for most of the real treatment subjects and suggest that larger, better matched groups should be run to confirm this. (1 reference)

0615 THE EFFECT OF EXTREMELY LOW FREQUENCY MAGNETIC FIELDS ON HUMAN PERFORMANCE: A PRELIMINARY STUDY. (E.) Gibson, R. S. (Naval Aerosp. Med. Res. Lab., Pensacola, Fla.) and W. F. Moroney. *Tech. Rep. No. NAMRL-1195*, 24p., 1974.

A research program is being conducted to determine whether man can be safely exposed to ELF electric and magnetic fields below 100 Hz. To identify and develop techniques to be used in this project, a set of tests were chosen to determine the following variables: (1) decision making and short-term memory; (2) coordination and dexterity in continuous and discrete modes; (3) long-term memory and concentration. Four standardized tests were chosen: the Response Analysis Tester (RATER) for decision making and short-term memory, the simplified electronic tracking apparatus (SETA) for coordination and dexterity in a continuous mode; Minnesota Rate of Manipulation Test (ROM) for coordination and dexterity in a discrete mode, and the Wilkinson Adding Test for long-term memory and concentration. Eleven male volunteer subjects between 18 and 28 were used, 6 as experimental subjects and 5 as controls. All biological functions were tested and found to be in the normal range for each subject. Tests were made before, during, and after a 24 hr exposure to a low intensity magnetic field at 45 Hz. Neither of the psychomotor tests used (SETA and ROM) yielded any significant results. Both of the cognitive tests yielded statistically significant results: the number of attempts on the Wilkinson adding test decreased during the second test session and the level 3 delay of the RATER showed a greater than expected increase in performance during the after exposure period. Consequently these 2 tasks should be considered for inclusion in any further studies concerned with the possible effects of ELF fields on human performance. (12 references)

0616 DEVELOPMENT OF DOSIMETRY FOR RF AND MICROWAVE RADIATION - I: DOSIMETRIC QUANTITIES FOR RF AND MICROWAVE ELECTROMAGNETIC FIELDS. (E.) Youmans, H. D. (Div. Biol. Eff., BRH, FDA, Rockville, Md.) and H. S. Ho. *Health Phys.* 29(2):313-316, 1975.

The biological effects of radiation result from the interaction of the radiation field and tissues. This interaction cannot be uniquely specified by a single

scalar value, power density, as is often done. The strength of the radiation and its interaction with tissues should be quantitatively expressed in a physically unambiguous manner which is causally related to areas of biomedical concern. The essence of dosimetry is found in the transport equations of the mathematical theory of radiation fields. The absorbed dose may be considered as the image of exposure under a transformation which accounts for the absorption, scattering, and geometrical properties of an irradiation condition, such that absorbed energy is the work done on matter by a field of radiation. Equations for energy flux density, absorbed dose rate and total power absorbed are given in terms of E and H, the electric and magnetic field strengths. With nonionizing radiation if a material is located in the near field of a radiation source, some of the absorbed dose will result from the nonradiated reactive components of the EM field and E and H inside the medium may be in a cross field relationship. The equations given allow for these contingencies. Also, in media of different permittivity and permeability, wave lengths may be different for the same frequency. Therefore, frequency is a more fundamental characteristic of an EMF and should be used. (6 references)

0617 DEVELOPMENT OF DOSIMETRY FOR RF AND MICROWAVE RADIATION - II: CALCULATIONS OF ABSORBED DOSE DISTRIBUTIONS IN TWO SIZES OF MUSCLE-EQUIVALENT SPHERES (E.) Ho, H. S. (Div. Biol. Eff., BRH, FDA, Rockville, Md.) and A. W. Guy. *Health Phys.* 29(2):317-324, 1975

Dosimetry in EM biological effects research has often been quantified in terms of energy flux density (incident power density), and results of animal experimentation have been directly compared to radiation protection guides. The power absorption characteristics of these animals may be drastically different for a given energy flux density than the power absorption of man. Biological effects are more directly related to absorbed dose rate. Theoretical expressions have been obtained for determining the absorbed dose rate distribution in a muscle equivalent sphere uniformly irradiated by a plane wave source. Calculations were made for single layered, muscle equivalent phantom spheres of 3 and 15 cm radii and different source frequencies (40 MHz to 10 GHz), illustrating the variation of absorbed dose rate with body size and source frequency. Strong standing wave patterns (hot spots) were found in the smaller sphere for all frequencies less than 5000 MHz. This is due to a focusing effect of the EMF inside a dielectric body when the size of the body is comparable to the wavelength of the radiation inside the body. For the 15 cm sphere, standing waves are in evidence at RF ranges. Above 5000 MHz, the absorption in both spheres becomes that of skin depth penetration. The calculations indicate that for a given energy flux density, the absorbed dose rate distribution depends on the size of the body and the source frequency of the plane wave. This is a drastic deviation in behavior from that of ionizing radiation. Specification of energy flux density alone may not be dosimetrically sufficient for relating results of biological effects experiments to radiation

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protection. Absorbed dose would be more appropriate. Further research is needed for calculations on models more closely resembling human bodies. (6 references)

0618 DEVELOPMENT OF DOSIMETRY FOR RF AND MICROWAVE RADIATION - III: DOSE RATE DISTRIBUTION IN TISSUE SPHERE DUE TO MEASURED SPECTRA OF ELECTROMAGNETIC PLANE WAVE. (E.) Ho, H. S. (Div. Biol. Eff., BRH, FDA, Rockville, Md.) and H. D. Youmans. *Health Phys.* 29(2):325-329, 1975.

The absorption characteristics for biological bodies irradiated simultaneously by RF and MW sources of different frequencies are unknown. Absorbed dose rate distributions have been calculated for two muscle equivalent spheres (6 and 30 cm diameter) exposed to measured EMR spectra. Data from measured spectra in the Washington, D.C. area, representing essentially far-field radiation from radio, TV, and radar transmitters, were used. Absorbed dose rate distribution was shown to depend strongly upon spectral concentration. When a dominant spectral line is present, the absorbed dose rate distribution resembled those caused by a single frequency source. Where no dominant lines exist, the exposure conditions of possible hazardous fields should be characterized in terms of spectral distributions. Further research is needed on man-equivalent models. (3 references)

0619 EXPOSURE OF THE JAPANESE QUAIL EMBRYO TO 2.45 GHz MICROWAVE RADIATION DURING THE SECOND DAY OF DEVELOPMENT. (E.) Hamrick, P. E. (Natl. Inst. Environ. Health Sci., Research Triangle Park, N. C.) and D. I. McRee. *J. Microwave Power* 10(2):211-221, 1975.

Based on previous works which showed effects from exposure at the 48 hr stage of development of the chick embryo, the effects of MW exposure during incubation of *Coturnix coturnix japonica* was investigated. Fertilized Japanese quail eggs (152) were positioned in holders with their long axes vertical and parallel to the E field vector of the MW field. They were exposed to 2.45 GHz CW radiation at a power density of 14 mW/g which could maintain them at 37 C. Exposure lasted for 24 hr on the second day of incubation. During exposure they were not turned. Before and after exposure, the eggs were kept in a commercial incubator with automatic turning and humidity control. The quail were kept for 24-36 hr before weighing, examining for gross deformities, and sacrificing. Blood samples were run for hematocrit, RBC, WBC, hemoglobin and differential white cell percentages. The quail were examined internally and externally for gross deformities and organ weights were determined for the heart, liver, gizzard, adrenals, and pancreas. No significant differences were seen between control and exposed birds although hemoglobin values were slightly lower (3.3%) for exposed quail. No gross abnormalities were seen, and no nonthermal effects were detected. Thus, 2.45 GHz CW microwave radiation at an observed power density of 14 mW/g does not prevent normal development of the quail embryo when exposed on the 2nd day of incubation. (25 references)

0620 MICROWAVE OVEN LABELING. (E.) Britain, V. A. (BRH, FDA). *FDA Consumer* 9(6):16-19, 1975.

The FDA has issued new regulations which are designed to reduce the possibility of injuries by requiring precautionary labels on ovens. These regulations require permanently attached labels on all MW ovens manufactured after October 3, 1975, which state that the oven should not be operated with an object caught in the door, with an improperly closing door, or with a damaged door, hinge, latch, or sealing surface. This decision was designed to make this information readily available to everyone who uses the oven. Precautions are necessary because of uncertainty about possible radiation effects. The original MW standard establishing a maximum limit on radiation leakage has also been recently amended to require that ovens include a system to detect failure of either of the interlocks and automatically render the oven inoperable until it is repaired. (No references)

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EFFECT OF ATP AND GLUTAMINIC ACID ON CARBOHYDRATE-ENERGETIC AND NITROGEN METABOLISM IN BRAIN AND LIVER OF RATS UNDER EFFECT OF PULSED ELECTROMAGNETIC FIELD. Mishchenko, L. I. (no affil.) and F. A. Kolodub. *Ukr. Biokhim. Zh.* 47(4):528-532, 1975.

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0162 ELECTROMAGNETIC FIELDS GENERATED FROM NEURONAL ACTIVITY. Anninos, P. A. (Sch. Med., Univ. California, Los Angeles).

See CR 0127, Volume II(2), for description of this research. (Renewed 9/74-8/75)

Supporting Agency:HEW, PHS, NIH

0163 NONINVASIVE SENSING OF SUBCUTANEOUS TEMPERATURES USING MICROWAVE THERMOGRAPHY. Barrett, A. H. (Massachusetts Inst. Technol., Cambridge).

This program, designed to evaluate the capability of MW radiometers to sense subcutaneous temperatures for medical diagnostic purposes, has reached the clinical evaluation stage. A radiometer operating at 3.3 GHz has been packaged for hospital use and is now in routine operation at Faulkner Hospital in Boston. The initial clinical application is the detection of sub-surface temperature anomalies associated with tumors of the breast. MW examinations are made in conjunction with the physician's clinical examination, IR thermography, mammography, and a biopsy examination. Conclusions about the usefulness of MW thermography must await the study of many more patients. A radiometer operating at 1.3 GHz is undergoing laboratory development and testing and will be used in the laboratory to check our experimental technique.

Supporting Agency:NIH

0164 INTERACTION OF ELECTROMAGNETIC FIELD WITH HUMAN BODY. Chen, K. (Sch. Eng., Michigan State Univ., East Lansing).

This research program will concentrate on the interaction of an EM field with the human body. A theoretical study will be conducted to determine the internal EM field induced inside the body and the external EM wave scattered by the body when it is illuminated by an EM wave. To check the accuracy of the theoretical results, an experimental study will be conducted to measure the electric fields induced inside of simple boxes containing saline solution and inside the phantom model which closely approximates the actual human tissues and torso. The theoretical method involves the numerical solution of a tensor integral equation for the electric field induced inside an irregularly shaped body. Various models of the human torso or other biological systems will be considered. It is anticipated that after the accuracy of the theoretical method is established a user-oriented computer program for the field calculations will be developed. (8/74-7/75)

Supporting Agency:NSF, Div. Eng.

0165 NAVY ENVIRONMENT: INVESTIGATION OF THE BIOLOGICAL EFFECTS OF PULSED ELECTROMAGNETIC FIELDS GENERATED BY NAVAL OPERATIONS. Cleary,

S. F. (Sch. Med., Virginia Commonw. Univ., Richmond).

HF, high intensity EMP fields can be produced by certain naval operations. Evidence points toward reversible effects in some biological systems. This research is an attempt to determine if the instantaneous field strengths and pulse characteristics of EMP are capable of producing biological alterations that may ultimately be of interest to man. This will be a study in 2 parts. The first will be a study of the effects of EMP fields on serum proteins, blood chemistry and drug-induced (pentobarbital) sleeping time in the Dutch rabbit. Comparisons will be made to recent findings in these areas due to MWs. The second phase of this work will be a study of EMP fields on an artificial biomembrane of known resistance, membrane potential and dielectric breakdown potential. These membrane properties will then be investigated as a function of the amplitude and pulse repetition rate of an applied EMP field. All exposures will be made using the EMP simulator at the Naval Weapons Laboratory, Dahlgren, Virginia. (7/74-6/75)

Supporting Agency:U.S. Dep. Def., Navy

0166 COMPARISON OF THEORETICAL AND EXPERIMENTAL ABSORPTION OF RADIOFREQUENCY POWER. Durney, C. H.; Johnson, C. C. (Sch. Eng., Univ. Utah, Salt Lake City).

Recent data indicate that the biological hazard of nonionizing EMR is frequency dependent, and body shape, size, and orientation are important variables affecting power deposition and subsequent hazard. The USAF is advocating a frequency related safety standard approach. The objective of this study is to extend theoretical RF power absorption calculations and to perform experimental measurements which are necessary for assessing realistic personnel exposure criteria in the 10 kHz to 100 MHz frequency range. Assessment techniques will account for size and orientation effects in extrapolating from animal to human RF exposure situations. A set of prolate spheroid models will be constructed to represent the rhesus primate and human. Theoretical calculations will be made to determine the amount of power absorbed for exposures between 10 kHz and 100 MHz. Power absorption measurements will be performed from 10-30 MHz and the results compared with theory. Rhesus primates will be exposed in the same geometry as the phantoms to evaluate anisotropic effects. The resulting data will be used to establish appropriate personnel exposure guidelines for a broader frequency range than can be measured with available experimental apparatus. (7/74-6/75)

Supporting Agency:U.S. Dep. Def., Air Force

0167 ELECTROMAGNETIC RADIATION STUDY OF TECHNIQUES FOR THAWING FROZEN ORGANS. Ecker, H. A. (Georgia Inst. Technol., Atlanta).

The development of EMR techniques for thawing frozen

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organs is a key feature in establishing a procedure for successful transplantsations of organs obtained from a frozen organ bank. The success of EMR to thaw frozen organs rapidly and uniformly depends on several parameters: (1) radiation frequency; (2) radiation modulation; (3) applied power level; (4) organ size; (5) dielectric constant of the organ tissue; (6) loss tangent of organ tissue; (7) cryoprotectant drug level in the organ; (8) thermal state of the organ; and (9) doping of the organ with a recoverable material. (3/75-2/76)

Supporting Agency: NSF, Div. Eng.

0168 REMOTE STIMULATION BY RADIOFREQUENCY TRANSMISSION. Glenn, W. W. (Sch. Med., Yale Univ., New Haven, Conn.).

This project is part of a broader program to support the Clinical Research Center at the Yale-New Haven Hospital and Yale University School of Medicine. Clinical investigations are conducted to obtain a better understanding of the mechanisms of disease and therapeutic measures are developed or tested. (10/74-9/75)

Supporting Agency: HEW, PHS, NIH

0169 MICROWAVE HEATING (HUMAN). Guy, A. W. (Sch. Med., Univ. Washington, Seattle).

This project is part of a broader program of the Center for Bioengineering which represents a multi-disciplinary research effort involving faculty and students from all the departments of engineering engaged in collaborative research with health scientists from many medical and dental disciplines. A comprehensive effort is directed toward transferring the fruits of biomedical engineering research and development to the health care delivery system. (10/74-9/75)

Supporting Agency: HEW, PHS, NIH

0170 DIAGNOSTIC AND THERAPEUTIC APPLICATIONS OF MICROWAVES (HUMAN). Guy, A. W. (Sch. Med., Univ. Washington, Seattle).

This project is part of a broader program briefly described in CR 0169, above. (10/74-9/75)

Supporting Agency: HEW, PHS, NIH

0171 NAVY ENVIRONMENT: LIQUID CRYSTAL FIBEROPTIC PROBES FOR MEASURING TEMPERATURE AND MICROWAVE FIELDS IN BIOLOGICAL MATERIALS. Johnson, C. C.; Durney, C. H. (Sch. Eng., Univ. Utah, Salt Lake City).

See CR 0088, Volume I(3), for description of this

research. (Renewed 7/74-6/75)

Supporting Agency: U.S. Dep. Def., Navy

0172 LABORATORY AND FIELD EVALUATIONS OF HEAT ENERGY TO CONTROL STORED-PRODUCT INSECTS. Kirkpatrick, R. L. (USDA, Stored Prod. Insects Res. Dev. Lab., Savannah, Ga.).

The objective of this study is to develop rapid sample and practical techniques in the laboratory and adapt these methods for field evaluations using heat, including IR and MW radiation, to control stored-product insects infesting grain or other stored commodities. Results of laboratory tests to determine the repellency, attractancy, effect on life history, behavioral responses, and dosage-mortality relationships of stored-product insects when exposed to different types of heat energy including that produced by IR or MW radiation will be evaluated in field tests. Research data obtained from these laboratory and field tests will be used to develop a practical and inexpensive commercial unit to control insects that infest stored commodities. (7/74-6/75)

Supporting Agency: USDA, Agric. Res. Serv.

0173 CONTRACTILE DEACTIVATION BY RAPID TEMPERATURE JUMPS. Lindley, B. D. (Sch. Med., Case Western Reserve Univ., Cleveland, Ohio).

Understanding of the kinetics of the processes controlling free intracellular calcium in intact muscle cells has been hindered by inability to achieve suitably rapid changes in membrane potential or intracellular concentration of chemical agents. Diffusion limitations are important in potassium and caffeine contractures of muscle bundles because of the interstitial space, in single fibers because of equilibration of the transverse tubules, and even in fibers free of sarcolemma because of the unstirred intracellular matrix. A MW temperature-jump system will be developed for the study of rapid-heating relaxation of single frog striated muscle cells. Digital averaging and repetitive pulsing will be used to increase resolution. This technique will be used in studying alterations of the calcium regulatory systems involved in excitation-contraction coupling in denervated muscle. It is also of great potential significance for the study of calcium regulation in heart muscle and secretory cells. (7/74-6/75)

Supporting Agency: Am. Heart Assoc.

0174 CLINICAL ASPECTS OF MICROWAVE EXPOSURE. Michaelson, S. M. (Sch. Med., Univ. Rochester, New York).

Evaluation of alterations in the functional status of the neuroendocrine system after exposure to MWs

and elucidation of threshold levels, cumulative effects, interaction with other stresses and environmental factors is the objective of this study. Mature rats will be exposed to MW irradiation in 3 different regimens: 100 mW/cm², 10 mW/cm², and 1 mW/cm² for 8 wk. Periodically throughout the exposure, body wt and temperature will be taken, and blood drawn. Gross behavioral observations will also be made. Thyroid function will be evaluated using T3 and T4 resin sponge absorption studies. Pituitary function will be determined by a bioassay of TSH. Mature dogs will be exposed to MW irradiation. Evaluation of changes in body wt, temperature, behavior, thyroid and pituitary function will also be carried out as with the rats. In addition, hematology, clinical chemistries, free T4, TSH and growth hormones by radioimmunoassay and serum electrophoresis will be studied. (7/74-6/75)

Supporting Agency: U.S. Dep. Def., Navy

0175 INTRAVITREAL SURGERY TECHNIQUES. Peyman, G. A.; Vlcek, J.; Goldberg, M. F. (Sch. Med., Univ. Illinois, Chicago).

The objectives of this study involve four problems related to intravitreal surgery: (1) establishment of an effective means of prevention and treatment of intraocular infection; (2) establishment of the feasibility of coagulation of intravitreal neovascularization with a RF probe, including a comparison of its efficacy to that of the organ laser currently used in occlusion of intravitreal neovascularization; (3) establishment of the feasibility of vitrectomy with emphasis on the best time to perform such surgery, i.e., the early or late stage of vitreous hemorrhage; (4) establishment of the use of vitrectomy in tractional detachment of the retina. Objectives 1, 2, and 3 have been completed in the past 2 yr and objective 4 remains as a goal for the coming year. (1/75-12/75)

Supporting Agency: HEW, PHS, NIH

0176 AN INVESTIGATION OF THE EFFECT OF MICROWAVES ON ISOLATED NEURONS. Wachtel, H.; Joines, W. (Sch. Arts, Duke Univ., Durham, N. C.).

The objective of this study is to investigate the effect of MW irradiation on the neurons of the marine mollusk *Aplysia*. Special emphasis will be given to the pacemaker cells which exhibit regular firing patterns in the absence of external stimulation. A neuron from the abdominal ganglion of *Aplysia* is pined out in a small chamber which is inserted into a MW stripline. The neuronal activity is monitored with intracellular microelectrodes. Both incident and reflected power are recorded. Theoretical as well as experimental determination of the absorbed power are made. (7/74-6/75)

Supporting Agency: U.S. Dep. Def., Navy

0177 CORRELATION OF ACOUSTIC AND BIOLOGIC PROPERTIES OF TISSUES. Ware, R.; Bhagat, P. K.; Lafferty, J.; Bradley, E. (VA Hosp., Lexington, Ky.).

The emphasis of this proposal is on determination of US acoustic properties of a representative group of tissues and measurement of acoustic differences correlating with different pathophysiologic conditions of tissue. To date, a study of the feasibility of a catheter tip imaging system suggests that US scanning offers more promise than IR or visible EM scanning, although continuous absorption/transmission measurements on dog blood throughout the entire IR spectrum out to 1 mm did show at least two regions of relative transparency. Future plans include completion of a laboratory measurement system, acquisition of acoustic and pathophysiologic data, compilation, analysis, and correlation of data; and application of basic information to practical medical instrumentation problems. (7/74-6/75)

Supporting Agency: VA

0178 RAPID MICROWAVE AND DIATHERMY THAWING OF FROZEN ORGAN GRAFTS MAINTAINED FOR TREATMENT OF BATTLE CASUALTIES. Denysyk, B.; Finch, E. (U.S. Navy Med. Res. Inst., Bethesda, Md.).

No descriptive information is available. (7/74-6/75)

Supporting Agency: U.S. Dep. Def., Navy

0179 GENETIC AND CELLULAR EFFECT OF MICROWAVE RADIATION. Dutta, S. K.; Chakravorty, A.; Blackman, C.; Brusick, D. (Sch. Lib. Arts, Howard Univ., Washington, D.C.).

The proposed research is directed at using a fast and highly sensitive battery of genetic tests and simple tests on cell morphological changes in order to evaluate the effects of low intensity MW radiation critically. Since the non-thermal (less than 1 mW/cm²) effects of MWs are difficult to distinguish from the thermal effects in large whole animal systems, their distinctions will be studied at the genetic level using systems well characterized for their thermal responses. Genetic alterations, such as gene-conversion, mutation and chromosomal deletion will be studied using repair-deficient his-mutants of *Salmonella typhimurium*; D-4 strain of *Saccharomyces cerevisiae*; ad 3A and ad 3B two-component heterokaryons; and excision repair-deficient mutants of *Neurospora crassa*. Gross morphological changes in development, using the filamentous fungus *N. crassa*, will be used to investigate chronic and delayed effects of CW and PW microwaves existing in our environment. Work will then be extended to study the alteration, if any, of repair processes by MW radiation using human fibroblast cultures. (7/74-6/75)

Supporting Agency: EPA, Off. Res. Dev.

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0180 BIOLOGICAL EFFECTS OF AF RF TRANSMITTER FIELDS. Frazer, J. W.; Merritt, J. H. (U.S. Air Force Sch. Aerosp. Med., Brooks Air Force Base, San Antonio, Tex.).

Firm foundations for EM safety standards for DOD personnel and the general population affected by DOD radiators depend on: (1) precise knowledge of the magnitude of the RF insult; (2) the relationship between insults and responses of experimental animals to those of man, (3) the bases on which the insult, in this case internal distribution of EM fields, act; and (4) the magnitude of insult levels no longer producing a measurable response. The objective of this effort is to investigate the biological consequences of AF aircrew exposures to unique RF radiation environments and to extrapolate the empirical findings to adjust personnel exposure criteria. Responses of experimental animals to field modulations said to be at frequencies of brain theta rhythm have been reported. The present hypotheses of high field Kerr effects and low field thermal distribution as major factors in inducing responses to EMR fields are at variance with assumed processes producing such effects. Field modulation effects, including pulsed fields, on a variety of CNS ionic and chemical distributions will be examined. Lymphocyte responses will be studied as a function of field amplitude in intact animals while culture responses are examined. (7/74-6/75)

Supporting Agency:U.S. Dep. Def., Air Force

0181 COMPARISON OF RF FIELD DELIVERY TECHNIQUES AND MEASURABLE RESULTS IN CELL CULTURE AND WHOLE ANIMALS. Guy, A. W. (Sch. Med., Univ. Washington, Seattle).

High level national concern over adequacy of existing RF safety standards has highlighted the need to be able to define experimental exposure fields accurately, to insure intercomparability of power deposition and mechanism of injury studies, and to validate theoretical predictions with measured distributions in experimental animals. This effort will investigate ground plane and position effects on power absorption in several man models at the University of Washington and at USAFSAM/RA. This project is designed to intercompare field measurement techniques used at the University of Washington and those used at USAFSAM, together with comparison of theoretical and measured distributions in experimental animals exposed in both facilities. An exposure system will be designed and constructed for cell or tissue cultures when fields within the culture can be exactly specified, and the utility of the culture system will be demonstrated by exposing freshly isolated *prima te* lymphocytes with and without stimulating antigens. The University of Washington personnel are to bring thermographic equipment and field measurement devices to USAFSAM to compare their measurements with those at USAFSAM. Killed animal models and physical models are to be examined after exposure to a variety of frequencies at USAFSAM and the University of Washington including the HF band coax, near field

synthesizer and the University of Washington resonant cavity, as well as provisional examination of the fields generated by the multiple frequency exposure apparatus at SAM. An exposure cell is to be constructed from readily available materials and its utility demonstrated by the exposure of freshly isolated lymphocytes to fields calculated for an equivalent field in man models exposed to a variety of field geometries. (7/74-6/75)

Supporting Agency:U.S. Dep. Def., Air Force

0182 ADVANCED BIOINSTRUMENTATION. Klein, H. P. (NASA, Moffett Field, Calif.).

The objective of this project is development of bioinstrumentation techniques to enable the measurement of biological, physiological and psychological responses of man and/or selected animal species to actual or simulated space flight conditions. Non-invasive, non-destructive testing procedures will be utilized for obtaining data wherever possible and feasible. Approaches will be directed towards development of instrumentation associated with measurement of central and peripheral cardiovascular function, bone mineral content, deep body physiological and physical functions, new and unique biochemical measurement techniques and methods of sample preservation. Among those developed will be techniques utilizing US and MW transducers as means for obtaining information from the body surface. (7/74-6/75)

Supporting Agency:NASA

0183 EFFECT OF MICROWAVE RADIATION ON AUDITORY SYSTEM. Konishi, T.; McRee, D. I., Hamrick, P. E.; Cook, R. O.; Yankwich, A. (Natl. Inst. Environ. Health Sci., Durham, N. C.).

See CR 0078, Volume I(3), for description of this research. (Renewed 7/74-6/75)

Supporting Agency:HEW, PHS, NIH

0184 VARIABLE FREQUENCY MICROWAVE EXPOSURE SYSTEM. McRee, D. I. (Natl. Inst. Environ. Health Sci., Durham, N. C.).

See CR 0076, Volume I(3), for description of this research. (Renewed 7/74-6/75)

Supporting Agency:HEW, PHS, NIH

0185 MICROWAVE EXPOSURE SYSTEM AND MICROWAVE DOSIMETRY. McRee, D. I.; Walsh, P. J. (Natl. Inst. Environ. Health Sci., Durham, N. C.).

See CR 0077, Volume I(3), for description of this

research. (Renewed 7/74-6/75)

Supporting Agency:HEW, PHS, NIH

0186 MECHANISMS OF NEUROENDOCRINE RESPONSE TO ELECTROMAGNETIC RADIANT ENERGY. Michaelson, S. M. (Sch. Med., Univ. Rochester, N. Y.).

Investigations are related to elucidating the mechanisms of HHT response to ionizing and nonionizing EMR. Studies are performed in the rat and dog to relate sequential changes in thyroid and pituitary function to thyroid hyperplasia, hypoplasia, and carcinogenesis seen after x-irradiation or functional changes reported during MW exposure. This involves partial as well as whole body irradiation, consideration of species differences in the neuroendocrine system, and proper scaling of animal results to man. Radioimmunoassays of specific hormones are applied to the study of homeostasis, impairment of physiologic capacity, and structural and functional integrity of the neuroendocrine system to assess the body's adaptive capabilities and pathophysiologic sequelae in general as a consequence of exposure to EMR. Detailed sequential analysis of thyroid and pituitary function in the development of thyroid and pituitary neoplasms is performed. Evidence is sought to ascertain axial (HHT) imbalance which could be a reflection of the coincident finding of pituitary adenomas and goiter in rats irradiated in the head and neck (1300 R, 250 kVp x-rays). TRH is used to determine whether thyroid dysfunction is due to injury to the thyroid gland per se (primary) or is related to hypothalamic-hypophyseal injury in localized head or thyroid x-irradiated dogs. The relationship between nonionizing EM heating of neuroendocrine components and resulting homeostatic shifts is also investigated. (7/74-6/75)

Supporting Agency:U.S. Energy Res. Dev. Adm.

0187 VENTILATION/BLOOD FLOW FUNCTION BY ELECTRO-IMPEDANCE. Nyboer, J.; Sedensky, J. A.; Thoms, N. (Sch. Med., Wayne State Univ., Detroit, Mich.).

The vascular and respiratory functions of the right and left lungs will be detected regionally by modulations of a transversely imposed RF field to the chest of normal and abnormal human subjects. It is proposed to classify the percentile disability of each lung or zone particularly in pre- and post-surgical conditions. An attempt will be made to arrive at ventilation-bloodflow indices and quotient for each lung. The impedance method of partitioning lung function is more practical and non-traumatic in comparison with obsolete bronchspirometry methods. Previous studies have found it comparable to dynamic Roentgen fluorodensitometric study of the lung. Our non-invasive electrical impedance research will define the functional effect of pneumothorax, infectious or traumatic pleuritis, pleural pericentesis, lobectomy, intrapulmonary or bronchial tumor, and

other chest problems. The principal investigative tool is Z, R, X detection by an advanced electrical impedance plethysmograph. (7/74-6/75)

Supporting Agency:Am. Heart Assoc.

0188 EFFECTS OF AIR FORCE TRANSMITTER RADIATION FIELDS ON BRAIN FUNCTION. Polis, B. D. (U.S. Navy Air Dev. Cent., Warminster, Pa.).

This research is designed to determine effects of RF radiation from Air Force EM transmitters on mammalian brain functions. Data will be used to establish human exposure criteria, safety standards (AFM 161-7) and hazardous exclusion areas. It directly supports safety criteria for 4141 OTH radar. High turnover systems most likely to be affected will be studied. Companion efforts in-house and at the Southwest Texas Medical School are investigating other neurotransmitters and brain energy metabolism. The phosphatides of blood have been uniquely defined as stress indicators. A carotid/sagittal sinus a/v difference has been shown and this difference is related to emotional states. Dogs are to be sacrificed with Nembutal anesthesia (30 mg/kg). Their brains will be removed and separated into mid-brain and anterior portions of cerebellum and medulla. Part of the tissues are utilized in-house to determine prostaglandin contents in another effort. Other parts are used for phosphatides studies. (7/74-6/75)

Supporting Agency:U.S. Dep. Def., Air Force

0189 EFFECTS OF MICROWAVE RADIATION AS FROM NAVY RADAR ON EMBRYONIC BRAIN TISSUE. Rioch, D. (Inst. Behav. Res., Silver Spring, Md.).

The general objective of this research is to determine whether there is a critical period (or periods) in the circadian rhythm of the rat fetus during which MW fields are effective in increasing the fetal growth, particularly the growth of the cerebral hemispheres. Holtzman (albino) rats which are pregnant will be exposed to 1700 MHz, 10 mW/cm² MWs from 1700-1800 hr on the 6th to 9th and 12th to 16th days of gestation. Additional rats will be similarly exposed overnight for 12-14 hr at 5 mW/cm². On the 20th day of gestation the rats will be sacrificed, fetuses weighed and brains removed and fixed in Bouin's solution. The gross form of the brains and their sizes will be studied under a dissection microscope. The brains will then be dehydrated and imbedded in paraffin for histological evaluations. (7/74-6/75)

Supporting Agency:U.S. Dep. Def., Navy

0190 ULTRASOUND CINE ANGIOCARDIOGRAPHY. Waag, R. C.; Gramiak, R. (Sch. Eng., Univ. Rochester, N. Y.).

A program will be initiated whose ultimate goal is the production of ultrasonic cross-sectional images of the solid structures of the heart and the intracardiac blood flow patterns in a motion picture format. Existing ultrasonic equipment, a sophisticated computer-controlled data acquisition system, computing facilities and a novel coded pulse ultrasonic rheometer will be used. The preliminary steps to be initiated in this research are the development of gray scale imaging of cardiac and intracardiac echoes by point imaging in a matrix to provide maximal signal intensity at any given point. Also, a program will be generated, probably through the medium of special moving target indicator methods for the differential display of solid structures as well as the moving blood. The 3rd portion involves the application of concepts which appear useful for imaging intracardiac blood flow data. These will include computerized Fourier analysis of RF signals detected by a conventional pulse echo ultrasonoscope and the adaptation of a prototype coded pulse ultrasonic rheometer. The latter research will stress the development of a single transducer operating mode to replace the two transducer method now in operation. (7/74-6/75)

Supporting Agency: Am. Heart Assoc.

0191 ANGIOGRAPHIC DIAGNOSIS AND CONTROL OF GI BLEEDING. Baum, S.; Athanasoulis, C.; Waltman, A.; Malt, R.; Fischer, J.; Coggins, C.; Galdabini, J. (Massachusetts Gen. Hosp., Boston).

This project is designed to attempt to improve radiographic and catheterization techniques of the GI examination by the use of magnification angiography. In addition, nonthrombogenic catheter materials will be evaluated and methods of superselective catheterization will be attempted, and a simple radiographic method of assessing blood flow in the mesenteric circulation will be evaluated. Another specific aim during the next grant period will be to try to answer the question of how long infusions are necessary to satisfactorily control arterial and venous bleeding. We will also attempt to determine the effect on the liver of hepatic arterial infusion of vasopressin. Various mechanical means of controlling gastro-intestinal hemorrhage will also be evaluated, which will include intraarterial RF coagulation, balloon catheters and injectable silastic catheters. Attempts will also be made to determine whether the superior mesenteric artery infusion with vasopressin results in a redistribution of total blood flow so as to increase renal perfusion of patients with Type II hepatorenal syndrome. (5/75-4/76)

Supporting Agency: HEW, PHS, NIH

0192 NAVY ENVIRONMENT: EFFECTS OF MICROWAVES ON MATURATION IN THE RAT. Michaelson, S. (Sch. Med., Univ. Rochester, N. Y.).

Other research has shown that MWs effect the growth

and development of the rat fetus when the exposure is properly placed during the gestational period. Brain growth appears to be most affected. This research will attempt to study how subsequent neonatal development and maturation of temperature regulation, which involves neural, hormonal and mutational facets, are modified by the in utero exposures. The development of the brain and ontogeny of temperature will be studied by exposing individual ratlets, previously exposed in utero, of specific ages to a mild cold stress (25-30 C) and measuring metabolism (O_2 consumption) and peripheral venous vasoconstriction. If a deficit appears, substrate, hormonal, or neural factors that may be responsible will be examined. Some animals will be decapitated for gross and microscopic examination of the brain. During the 2nd year, power density/time relationships will be developed on the basis of body surface. (7/74-6/75)

Supporting Agency: U.S. Dep. Def., Navy

0193 MATERIALS SUPPORT TECHNOLOGY: MICROSTRUCTURE-DEPENDENT MECHANICAL PROPERTIES OF VIABLE CORTICAL BONE. Black, J. (Sch. Med., Univ. Pennsylvania, Philadelphia).

The static and dynamic properties of individual and groups of osteons excised from characterized cortical bone, including elastic moduli, fatigue behavior, and strength, are to be measured by a MW method under true physiological conditions. Stress-strain curves (tensile or compressive) will be determined for driving force frequencies between 0.01 and 100 Hz. Mineralization, collagen orientation, and bone character will be correlated with behavior of individual osteons. An extensive analysis will be made of literature reports of dynamic micromechanical properties of bone under various conditions: Deviations in behavior as a result of frequency, structural features, and viability will be emphasized. Analytical calculations of osteons as 2 phase bodies under constant strain in the load axis will be made to determine their contribution to the micromechanical behavior of cortical bone. (7/73-6/74)

Supporting Agency: U.S. Dep. Def., Navy

0194 BEHAVIORAL EFFECTS OF NONIONIZING ELECTROMAGNETIC RADIATION ON STORED-PRODUCT INSECTS. Bruce, W. A. (U. S. Dep. Agric., Savannah, Ga.).

The objectives of this project are to determine the EM frequencies to control and/or alter insect behavior and to provide working models, based on insect physiology, morphology and behavior, by which economical, nonchemical control might be accomplished. Insects will be exposed to various frequencies and intensities to determine response, thresholds, and probable locations of sensory receptors. Precise receptor location will be accomplished electrophysiologically. Because of the increased power and wavelength penetrability of laser-produced IR radiation, IR spectrum studies will be run. These will utilize

frequencies produced by gas lasers to determine feasibility of using laser technology and techniques for behavioral work involving insect detection of and attraction/repulsion to these frequencies. The principle of differential absorption of laser-produced frequencies between commodity and insect will be utilized for possible detection and control of the infestation within the commodity. (7/74-6/75)

Supporting Agency:USDA

0195 QUANTITATIVE EFFECTS OF EM ENERGY ON HUMAN TISSUES. Guy, A. W.; Lovely, R. H.; Lehmann, J. F.; Galambos, R. (Sch. Med., Univ. Washington, Seattle).

See CR 0008 and CR 0036, Volume I(1) and CR 0068, Volume I(2), for previous descriptions of this research. Work will be continued on the improvement of dosimetric and exposure techniques in the 100 MHz-10 GHz frequency range, including small animal, *in vitro*, partial human body and whole human body exposures. In addition, work on the circular waveguide that uses circular polarized TE11 mode for chronic exposure of small animals and illumination of *in vitro* cell culture preparations will be completed. The high power exposure system will also be completed and calibrated for exposing both full scale and phantom models of animals and scaled models of man, in order to quantify MW coupling characteristics to various subjects over a wide frequency band. Once absorption characteristics are determined for the models, birds will be irradiated as described in the overall proposal, in order to show the relationship effects as a function of body size and frequency. Research on the evaluation of various diathermy applicators, with the aim of providing more efficient coupling between a given laboratory generator and a region of the biological system where deposited energy is desired, will be continued. In this regard, applicators will be developed for improving energy transfer to the CNS or the head of an animal so that studies relating pulsed MW fields and auditory hearing phenomenon may be conducted at the neurophysiological level of analysis. Specifically, the frequency range at which pulsed MWs are heard and the nature or mechanics of the transducer for the hearing of pulsed MWs will be investigated. Finally, a major effort will be made in the coming year to evaluate power absorption patterns in human tissues exposed to current diathermy apparatus, and to relate these findings to current safety standards for human exposure. (Renewed 6/75-5/76)

Supporting Agency:HEW, PHS, FDA

0196 EFFECTS OF 2450 MHz MICROWAVE RADIATION ON BIOLOGICAL MATERIAL AT CELLULAR LEVEL. Hamrick, P. E.; Zinkl, J. (HEW, PHS, NIH, Durham, N. C.).

See CR 0074, Volume I(3), for description of this research. (Renewed 7/74-6/75)

Supporting Agency:HEW, PHS, NIH

0197 EFFECTS OF 2450 MHz CW MICROWAVE RADIATION ON THE EMBRYONIC DEVELOPMENT OF JAPANESE QUAIL. Hamrick, P. E.; McRee, D. I.; Zinkl, J.; Thaxton, P.; Parkhurst, C. (HEW, PHS, NIH, Durham, N. C.).

See CR 0075, Volume I(3), for description of this research. (Renewed 7/74-6/75)

Supporting Agency:HEW, PHS, NIH

0198 BIOPSYCHOLOGICAL STUDIES OF MICROWAVE IR-RADIATION. Justesen, D. R. (Sch. Med., Univ. Kansas, Kansas City).

See CR 0001, Volume I(1) and CR 0065, Volume I(2) for previous descriptions of this research. Microbial organisms, mice, rats, guinea pigs, and rabbits have been exposed to intense fields of 2450 MHz MW energy in the multi-mode cavity in studies of ultrastructural, teratological, thermal, behavioral, and growth responses to radiation. At rates of dosing exceeding 40 mW/g and durations of radiation of many hours, there are reliable differences in parameters of growth and in ultrastructure of microbial (bacterial and fungal) organisms as compared to conventionally thermalized controls. At rates of dosing below 40 mW/g and durations less than 25 min, radiated mammals seldom differed reliably from nonradiated controls except for the observation that fetal radiation improved survival of mice treated *in utero* with a teratogenic agent. (Renewed 6/75-5/76)

Supporting Agency:HEW, PHS, FDA

0199 NAVY ENVIRONMENT - BIOMEDICAL EFFECTS OF RADIOFREQUENCY RADIATION. Lin, J. C.; Kraus, G. E. (Sch. Eng., Wayne State Univ., Detroit, Mich.).

The Navy is attempting to establish a sound basis for exposure standards. This research will be a part of the effort to determine the potential for hazard in the 50-300 MHz frequency range. This study will investigate the effect of RF radiation on the growth, reproduction and pathology of mice. The mice will be exposed, both acutely and chronically, in a parallel strip transmission chamber where plane wave fields with variable E/H ratios can be produced. Temperature distribution and patterns will be established. Phantom models of both mice and man will be used to establish correlations. (7/74-6/75)

Supporting Agency:U.S. Dep. Def., Navy

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